BULLETIN OF THE IMPERIAL INSTITUTE

A RECORD OF PROGRESS RELATING TO AGRICULTURAL, MINERAL AND OTHER INDUSTRIES, WITH SPECIAL REFERENCE TO THE UTILISATION OF THE RAW MATERIALS OF THE DOMINIONS, INDIA AND THE COLONIES

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BULLETIN OF THE IMPERIAL INSTITUTE

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CONTENTS

CONTENTS

ARTICLES—*continued*

NOTES

NOTES—*continued*

RECENT RESEARCH ON EMPIRE PRODUCTS

BIBLIOGRAPHY

CONTENTS

ERRATUM

Page 387, line 23, *for* Windward Islands, *read* Leeward Islands

LIST OF ILLUSTRATIONS

BULLETIN
OF THE IMPERIAL INSTITUTE

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FOREWORD

Now that we have undertaken, with the approval of the Board of Governors, to publish our quarterly BULLETIN at the Imperial Institute, it is only right that we should explain the history and scope of the new venture.

The BULLETIN was first issued in 1903, the then Director (Professor Dunstan, now Sir Wyndham Dunstan) being the Editor. For the first two years it was published as a Supplement to the *Board of Trade Journal*, but in 1905 we took it over ourselves as a separate publication, and this arrangement remained in force until 1912. During this period the BULLETIN comprised articles and notes on the principal economic products of the British Empire, animal, vegetable, and mineral, as well as reviews of books. Notes on the Galleries and on other activities of the Institute were also included.

In 1912, publication was entrusted to Mr. John Murray, and that distinguished firm fully justified its selection for the task during the years which followed. The BULLETIN was enlarged and articles contributed by authorities outside the Institute became a feature of the publication. Prior to this the matter had been prepared by the Scientific Staff of the Institute, who still provide the bulk of the contributions as part of their official duties.

In 1919, the Imperial Mineral Resources Bureau was formed to deal with certain classes of work on minerals which had previously been allocated to the Imperial Institute. The Imperial Institute BULLETIN continued, however, to deal with mineral resources of the Empire as well as with plant and animal products.

In 1926, after the amalgamation of the Imperial Mineral Resources Bureau with the Imperial Institute, it was decided to concentrate the activities of the Intelligence Section of the Mineral Resources Department on answering enquiries and on writing brochures; and mineral contributions to the BULLETIN declined in consequence.

But the result was, not unnaturally, a decline in the number of subscribers to the BULLETIN. By reintroducing, as from the current number, articles, notes, bibliography, etc., on mineral resources, it is hoped to interest a wider public than that at present reached. The opportunity is also being taken to reduce the price from 15*s.* annually to 10*s.* post free, and to insert a page or two dealing with popular developments in our Exhibition Galleries and Cinema.

A further innovation has been the elimination of all paid advertisements from the BULLETIN and, instead, the exchange of free advertising matter with associations and societies which recognise and practise the study of economic, cultural or educational interests of the Empire.

We look forward to the future of the BULLETIN with a confidence based not merely on optimism but rather on such care and forethought as we can command to carry us forward on our new venture.

May we take this opportunity to remind our readers of the broad principles set before the Institute in terms of the Imperial Institute Act of 1925, as reproduced on p. 3 of this issue? It will be our duty so to order the contents of the BULLETIN in the future, as in the past, that it will assist in making known to the general circle of our readers the practical application of the principles of Empire development and enlightenment which the Institute was designed to foster and for which it stands.

THE IMPERIAL INSTITUTE

SCOPE OF ACTIVITIES

THE Imperial Institute was founded as the Empire Memorial of the Jubilee of Queen Victoria. The purposes of the Institute, as defined by the Imperial Institute Act of 1925, are as follows :—

1. To promote the commercial, industrial and educational interests of the British Empire.

2. To collect and disseminate :—

(*a*) information relating to possible uses of and markets for new raw materials or semi-manufactured products ;

(*b*) information relating to new uses of and markets for already-known raw materials or semi-manufactured products ;

(*c*) information relating to sources, production, supplies, cost, consumption and requirements of raw materials and semi-manufactured products and legislation relating thereto ;

(*d*) information relating to the best means of increasing supplies or of creating new sources of supplies of such materials and products within the Empire ;

(*e*) information relating to the best means of treating such materials and products and of preparing them for marketing ;

(*f*) technical and scientific information bearing upon the industries of the British Empire.

3. To advise on the development of the resources of the Empire in raw materials in order that such resources may be made available for the purposes of industry and commerce and of Imperial defence.

4. To conduct in the laboratories of the Institute preliminary investigations of raw materials and, when it may be deemed advisable, to arrange for more detailed investigation by appropriate scientific or technical institutions.

5. To collect samples of raw materials having a definite value in industry and commerce.

6. To co-operate with other agencies within the Empire formed for similar purposes.

7. To maintain for public information and instruction in the Exhibition Galleries of the Imperial Institute exhibitions illustrative of the resources and development of the Empire and of its scenery, life and progress and where practicable to organise from time to time temporary exhibitions of a similar nature elsewhere.

8. To do anything incidental to or conducive to carrying into effect all or any of the foregoing purposes.

Under the provisions of the Act aforementioned, the Institute was reorganised and placed under the control of the Department of Overseas Trade. The Parliamentary Secretary of that Department is the responsible Minister and is President of the Board of Governors. This body consists of the High Commissioners of the Dominions and India, representatives of the Colonial Office and certain other Government Departments, and of the Crown Agents for the Colonies, with additional members representing scientific and commercial interests. A list of the Board of Governors will be found on p. 8. The Director of the Institute is Sir Harry A. F. Lindsay, K.C.I.E., C.B.E.

The technical work of the Institute is carried out by two principal Departments, viz. a Plant and Animal Products Department and a Mineral Resources Department. An Advisory Council for each of these groups of products has been appointed, Mr. F. A. Stockdale, C.M.G., C.B.E., being Chairman of the Plant and Animal Products Council, and Sir William Larke, K.B.E., Chairman of the Mineral Resources Council.

A number of Advisory Technical Committees consisting of authorities on the various groups of raw materials co-operate in the work of the Institute, in association with the Advisory Councils, and a close touch is maintained with producers, users, merchants, and brokers. Valuable help can thus be given by the Institute to persons interested in the development of raw materials throughout the Empire.

Enquiries.—The Institute maintains a special service for dealing with enquiries relating to the sources, production, uses and marketing of raw materials and for collecting and disseminating general and statistical information on these subjects. This service is available for the use of individuals and firms, as well as of Government Departments.

Investigations.—The laboratories of the Institute are specially equipped for the chemical and technical examination of raw materials of all kinds. Full reports are furnished on the composition, uses and value of materials submitted. By its close association with the users of raw materials, the Institute is able to arrange large-scale trials of promising materials when necessary.

Investigations on plantation rubber are conducted at the Institute under the supervision of the London Advisory Committee of the Ceylon Rubber Research Scheme and the Rubber Research Institute, Malaya.

Charges for Enquiries and Investigations.—Enquiries and investigations are conducted without charge for Governments which contribute to the general revenues of the Institute. In the case of non-contributing Governments fees on a moderate scale are charged for any work involving a considerable expenditure of time and trouble, while simple enquiries and preliminary investigations, easily carried out, are not charged for. Work is carried out for private firms and individuals, at home and overseas, in general on the same terms as for non-contributing Governments.

Library.—The Library of the Institute contains a large collection of works of reference relating to Empire countries and their products and is regularly supplied with the more

important reports and other publications of Government Departments in Great Britain, the Dominions, India, the Colonies and most foreign countries. More than 800 serial publications, mainly of a scientific or technical character, are also regularly received.

The library is available for the use of enquirers between the hours of 10 a.m. and 5 p.m. on week-days (10 a.m. and 1 p.m. on Saturdays).

Statistical Section.—This section is concerned with the collection of statistics required in connection with the work of the Institute.

Publications.—The BULLETIN OF THE IMPERIAL INSTITUTE contains records of the principal investigations conducted at the Imperial Institute, and articles and notes, chiefly relating to progress in tropical agriculture and forestry, the development of mineral resources, and the industrial utilisation of all classes of raw materials. A summary of research work conducted by Government Technical Departments overseas, a special bibliography of publications received in the library of the Imperial Institute and book reviews are also included.

Other publications of the Institute include a handbook on "The Agricultural and Forest Products of British West Africa"; a Descriptive List of Some Empire Timbers; a Report on Grading Rules and Standard Sizes for Empire Hardwoods; a Monograph on the Tanning Materials of the British Empire; Reports on the Collection of Reptile Skins for Commercial Purposes and the Drying of East African Hides; a comprehensive series of some fifty Brochures covering all the important economic minerals and metals under the title of "The Mineral Industry of the British Empire and Foreign Countries"; an Annual Statistical Summary showing production, imports and exports, British and foreign, of all the metals and minerals dealt with in the Brochures; a Survey of the Mineral Position of the British Empire; a series of twelve volumes on the Mining Laws of the British Empire; and one dealing with Mining Royalties and Rents in the British Empire. A list of the publications is obtainable on request.

Public Exhibition Galleries.—Visitors to these Galleries find each country of the overseas Empire represented by a Court of its own in which the home life, scenery and industries are artistically reproduced by means of photographic transparencies, photographs and dioramas. Where possible these exhibits are so arranged on the principle of the " travelogue " that the visitor is taken in imaginative sequence through just those scenes which would have met his eye had he been making the actual trip. Specimens of economic products are also exhibited; and, where possible, the specimens are grouped so as to tell the story of the industry concerned. By this means the lessons taught in text-books of geography or of technical industry are reinforced by the system which has now come to be known as " visual instruction." Lectures and demonstrations in the Galleries are given daily to school teachers and school children by the Guide Lecturers.

At the Central Stand, which is situated at a central point in the Exhibition Galleries, free literature relating to Empire countries and products is distributed and other publications and picture postcards on Empire subjects are on sale.

In the Exhibition Pavilion attached to the Galleries, temporary exhibitions of a commercial or educational character are held from time to time.

The Galleries are open free on week-days from 10 a.m. to 5 p.m., and on Sunday afternoons from 2.30 to 6 p.m.

Cinema.—The Imperial Institute maintains a Cinema Theatre in the Exhibition Galleries. The Cinema is equipped with standard size projectors and screen, and modern lighting, heating and ventilating systems, and has seating accommodation for 370 persons. Films illustrating life and industries in the various countries of the Empire are shown daily at 10.15, 11.35, 2.15, and 3.35 (Sundays 2.45 and 4.15). Special arrangements are made for visits of organised parties from schools and educational institutions. Lectures on industries and countries of the Empire are frequently given in addition to the ordinary cinema displays.

Empire Film Library.—The Empire Film Library was inaugurated at the Imperial Institute by H.R.H. the Duke of Gloucester on Friday, June 14, 1935, in commemoration of His late Majesty's Silver Jubilee. It contains a large collection (850 at the end of 1935) of cinematograph films depicting industries and agriculture at home and the life and products of Empire countries overseas. The films are available for loan to schools and other approved bodies in Great Britain without other charge than the cost of their carriage both ways. A catalogue of the library is available for distribution.

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REPORTS OF RECENT INVESTIGATIONS AT THE IMPERIAL INSTITUTE

Selected from the Reports made to the Dominion, Indian and Colonial Governments

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FURTHER EXPERIMENTS ON THE IMPROVEMENT OF AFRICAN HIDES

IN 1932 a series of experiments was carried out in Kenya Colony for the purpose of ascertaining the conditions conducive to the development of " blister " and " taint " in East African hides, and with a view to devising a method of drying which prevented the development of such damage and was capable of being followed in districts where shade drying was impracticable. The experiments were conducted by the Division of Animal Industry, Kenya, under a scheme which had been drawn up by the late Mr. Eustace Montgomery, Adviser on Animal Health to the Secretary of State for the Colonies, who was a valued member of the Imperial Institute Advisory Committee on Hides and Skins.

The scheme involved the special preparation of 1,000 hides for detailed examination in this country, which included reports by merchants and brokers on the condition of the raw hides as received, tanning trials and the examination of the resulting leather by technical experts. The reports received from all these sources were finally incorporated in a detailed report issued by the Advisory Committee, which was published in this BULLETIN (1934, 32, 41), and also as a separate pamphlet.

The results showed that free exposure of both sides of the hide during drying is the chief factor in preventing blister and general putrefactive damage and a simple improved method of sun-drying suitable for native use, based on this result, was recommended. A description of the method is given on pages 20-21.

The Committee's Report was widely distributed in all Empire countries where hides are prepared by natives and created considerable interest. One outcome of the report was a further series of experiments on similar lines conducted by the Government of Southern Rhodesia during November and December 1934. The hides prepared in these trials were sent to this country for detailed examination in the same way as in the case of the Kenya hides. The report on the hides, which has been prepared by the Imperial Institute Advisory Committee on Hides and Skins, has now been despatched to the Government of Southern Rhodesia and is here printed for general information. A set of twelve bends of leather representative of the twelve experiments was furnished to Southern Rhodesia, together with a set of photomicrographs of the leather. A selected series of bends is available for inspection at the Imperial Institute.

The results demonstrate the excellent quality of hides prepared by the method recommended by the Committee and further trials in other countries producing native-cured hides can be safely recommended.

HIDES FROM CURING EXPERIMENTS IN SOUTHERN RHODESIA

REPORT BY THE IMPERIAL INSTITUTE ADVISORY COMMITTEE ON HIDES AND SKINS

INTRODUCTION

THE experiments were initiated by the Government of Southern Rhodesia for the purpose of improving the quality of native hides prepared in the Colony, in the export of which there is a great annual wastage in value due to faulty or careless methods of curing and preparation.

The Department of Agriculture and Lands carried out the experiments in co-operation with the Rhodesian Export and Cold Storage Company at the Company's works at Bulawayo, the experiments being viewed by farmers and others while in progress.

SCHEME OF EXPERIMENTS

The experiments were modelled to a certain extent on the scheme of investigation drawn up by the Committee

and carried out by the Government of Kenya in 1932, the results of which were published in the Imperial Institute Report, "The Drying of East African Hides." The modified method of sun-drying hides which the Committee recommended as a result of that investigation, for employment where shade-drying is impracticable, was included in the programme.

The hides were cured by six different methods (Groups 1 to 6), carried out in dry weather (Lots A) and repeated in a showery period (Lots B). For each of the twelve experiments 6 to 15 hides were employed, amounting to a total of 121 hides.

Details of the experiments and of the hides and curing times, compiled from information supplied by the Department of Agriculture, form Appendices A and B respectively to this report. Meteorological data furnished by the Department for the periods of curing are given in Appendix H.

Examination of the Cured Hides

The investigation of the cured hides was undertaken by the Imperial Institute at the request of the Government of Southern Rhodesia, a report on the respective quality and value of the different groups of hides being desired.

The hides on arrival at the Institute were inspected by members of the Advisory Committee on Hides and Skins. Reports on the raw hides are given as Appendix C (by the Chairman, Dr. Jordan Lloyd, and the Secretary, Dr. J. R. Furlong), and Appendix D (by Mr. H. W. Chadwick, of Messrs. Chadwick and Hollebone), and in Appendix E (by The Penketh Tanning Co. Ltd.).

Tanning Trials

The hides were transferred to The Penketh Tanning Co. Ltd. and put in work. They were given a vegetable tannage and finished as sole leather. The firm's report on the raw hides and on the limed pelts (i.e. the hides after they had been soaked, limed, dehaired, and fleshed) forms Appendix E.

The finished leather was examined by the Chairman and Mr. R. Withinshaw (Penketh Tanning Co. Ltd.), whose report is given as Appendix F.

A microscopical examination of the corium of the leather from each experiment was made by the British Leather

Manufacturers Research Association, a summary of the report forming Appendix G.

Conclusions

The reports furnished on the hides at various stages from raw hide to finished leather were considered by the Committee, the reports on the limed pelts and on the finished leather being of most importance in deciding the merits of the curing methods. In this connection it will be observed that damage not detected by an inspection of the raw hides was disclosed on working the hides in the tannery, particularly in respect of Group 4.

Group 1. *Pitting.*—The majority of hides in this group showed tender grain, with the result that when finishing the leather small patches of weak grain were rubbed off in the process. This method of curing hides with salt in pits must therefore be considered as unsatisfactory.

Group 2. *Dry-salting.*—The leather produced from the hides cured by this method was generally of excellent quality.

Group 3. *Shade-drying.*—The leather resulting from this method of curing was excellent.

Group 4. *Sun-drying on the Ground.*—The hides cured by this method were badly blistered and in the tanning trials yielded very poor results.

Group 5. *Sun-drying by Suspension as Recommended by the Imperial Institute.*—The leather from hides of this group was of excellent quality.

Group 6. *Sun-drying over Poles.*—Although the hides cured by this method yielded leather of good quality in general, 50 per cent. of the hides gave leather showing damaged grain and cracked leather along the line of the back where the hide had been in contact with the pole. This method is, therefore, less satisfactory than the methods employed in Groups 2, 3, and 5.

There was no appreciable difference in value between the leather produced from the two lots A and B in each group of hides (i.e. hides cured in dry and in showery weather respectively). It must be concluded that the contrast in the weather conditions was not sufficiently marked to have an influence on the results.

From this investigation the curing methods which have yielded the best results and which can be recommended are :—

Group 2, Dry-salting.

Group 3, Shade-drying.

Group 5, Sun-drying by suspension, as recommended by the Imperial Institute.

Of these three methods that of Group 5 is the simplest. It has the advantage over the dry-salting method of Group 2 that no salt is required, and an advantage over the shade-drying process of Group 3 as no covering in the form of a roof is employed. Moreover, it can be carried out by the small farmer or native dealing with only a few hides at a time. There was no material difference in the quality of the leather from the three groups. It may be mentioned here that there is a stronger world demand for dried hides than for dry-salted ones.

The sun-drying method on the ground, by which the hides of Group 4 were prepared, is condemned as highly unsatisfactory.

Pitting (Group 1) and sun-drying over poles (Group 6) cannot be recommended on the results of these experiments.

In arriving at the above conclusions defects which had nothing to do with the method of curing were disregarded. In view of these defects (worm damage, branding, flaying cuts, damaged grain due to horn raking and thorn scratches) occurring to varying degrees in the different groups, it would be unfair to state the money value of the hides in each group, and regard such prices as an index of the merits of the various methods of curing. The value of the respective methods may, however, be stated as follows.

The hides prepared by shade-drying (Group 3, A and B) and by sun-drying by suspension (Group 5, A and B) were excellent and would realise the highest prices. Hides of Group 2, A and B were also excellent, but being dry-salted would realise a lower price, proportionate to the lower yield of leather given by salted hides.

Hides of Group 6, A and B (sun-dried over poles) would realise ½*d.* per lb. less than those of Groups 3 and 5 owing to crackiness along the back-bone line; 50 per cent. of the hides showed this defect, which if present to a greater extent would still further reduce the value. Although the hides in

Group 2, dry-salted, and in Group 3, shade-dried, were also dried over poles, no ill effects of the poles were noticeable in the finished leather from these groups. This may possibly be accounted for by the slower drying of these hides under cover.

The sun-dried hides of Group 4, A and B, were very poor and would realise 3*d*. per lb. less than the hides of the better groups, thus falling far below all the other groups in value. A comparison in price terms of the pitted hides cannot be made, owing to the cure being a wet one.

In conclusion it may be stated that the examination of the leather has shown the hides used in these experiments to be of excellent quality as regards leather-forming properties. The defects present, to which attention has been drawn, are those due to preparation and handling. The hides when properly taken off and treated should be of high-class quality.

January 14, 1936.

APPENDIX A

DETAILS OF EXPERIMENTS

The hides, after being washed free from blood and dirt in all cases, were cured by six different methods, as follows :—

Group 1. *Pitted.*—The hides were placed in a pile flesh side up in a pit, salt being sprinkled freely on the flesh side. The hides remained in their own liquor for about 20 days, after which they were stacked to drain, re-stacked once or twice, and then bundled.

Group 2. *Dry-salted.*—The hides were salted very evenly, stacked for five days and then dried over poles, flesh side up, in an iron shed with open sides.

Group 3. *Shade-dried.*—The green hides without salt were hung over poles, flesh sides up, in a shed until dry.

Group 4.—*Sun-dried on Ground.*—The green hides without salt were opened (not stretched) on the ground, flesh sides up, until dry. The idea was to have a group cured in the ordinary native way.

Group 5. *Sun-drying Method Recommended by the Imperial Institute.*—Full particulars of this method are given in the Imperial Institute Report, "The Drying of East African Hides."

In this method the hides are suspended from horizontal

poles which are in a line running east and west and at a suitable distance from the ground.

The tail butt and hind shanks of the hide are tied to the pole with ropes, while the head and fore shanks of the hide are tied to pegs in the ground, the hide being free of the ground. The pegs are placed on the line of the shadow thrown by the horizontal poles at mid-day. The hide is thus stretched at an angle with the ground, flesh side uppermost. At intervals, of perhaps a week or so, the line of pegs is adjusted to correspond with the shadow of the pole, which will have altered owing to the sun's position. The daily variation will not be large enough to be worth consideration.

By this method the hide is freely exposed on both sides for drying, a factor of prime importance; any rain which falls on the hide runs off and the hide is exposed to the sun in such a manner that the rays fall very obliquely on it. The sun's effect is, therefore, less than when the rays beat directly on a hide stretched out flat on the ground.

The method does not necessitate so much equipment as is required for shade-drying and is suitable for general application in both dry and wet seasons.

Group 6. *Sun-dried on Poles.*—The green hides, without salt, were hung, flesh sides up, over poles in the sun. Daily at noon they were turned so that the flesh and hair sides were exposed to the sun for the same length of time.

In Groups 2, 3, and 6 the hides were put over the poles along the backs from neck to tail.

Each Group of hides consisted of two lots—A and B.

Lots A, Dry Weather, were cured during a period of hot, sunny weather, and *Lots B, Showery Weather,* during a period of rainy, cloudy weather.

No great differences were anticipated between Lots A and B in Groups 1, 2, and 3 as they were all cured under cover.

Lots B in Groups 4, 5, and 6 were all exposed to rainy, cloudy weather and were soaked with rain several times before they were sufficiently dry to be taken into the shed. It was not anticipated that they would be of the same quality as the Lots A hides (in Groups 4, 5, and 6), which were cured in beautifully sunny weather.

While Groups 1 and 2 represent the methods followed by large firms, Groups 3, 5, and 6 represent methods which could

be generally adopted by farmers and by natives in the Colony in preference to the method of Group 4, which is at present commonly used.

APPENDIX B

DETAILS OF HIDES AND CURING TIMES

A—Cured in Dry Weather.
B—Cured in Showery Weather.

All weights in lb.

Group 1. Pitted

A

No. of Hides.	Green weight, 8-11-34.	Cured weight, 29-11-34.	Bundled weight, 14-12-34.
14	915	789	834
Average	65·4	56·4	59·6

Hides cured and taken out of pit on 29-11-34.
Forwarded in wet, salted condition.

B

No. of Hides.	Green weight, 22-11-34.	Cured weight, 12-12-34.	Bundled weight, 14-12-34.
6	422	361	378
Average	70·3	60·2	63

Hides cured and taken out of pit on 12-12-34.
Forwarded in wet, salted condition.

Group 2. Dry-Salted

A

No. of Hides.	Green weight, 8-11-34.	Cured weight, 29-11-34.	Bundled weight, 14-12-34.
14	917	477	493
Average	65·5	34·1	35·2

Salted and stacked 8/11 to 13/11 and then put over poles. These hides, owing to the large amount of salt on them, took long to dry and were only considered "dry" on 22-11-34.

Drying time—9 days.

B

No. of Hides.	Green weight, 22-11-34.	Cured weight, 12-12-34.	Bundled weight, 14-12-34.
6	426	213	222
Average	71	35·5	37

Salted and stacked 22/11 to 27/11 and then put over poles. With every shower of rain the salt on the hides absorbed moisture and the hides were only considered "dry" on 11-12-34.

Drying time—14 days.

Group 3. Shade-Dried

A

No. of Hides.	Green weight, 8-11-34.	Cured weight, 29-11-34.	Bundled weight, 14-12-34.
14	914	407	392
Average	65·3	29·1	28

Considered "dry" on 16-11-34.
Drying time—8 days.

B

No. of Hides.	Green weight, 22-11-34.	Cured weight, 12-12-34.	Bundled weight, 14-12-34.
6	414	176	168
Average	69	29·3	28

Considered "dry" on 3-12-34.
Drying time—11 days.

Group 4. Sun-Dried on Ground

A

No. of Hides.	Green weight, 8-11-34.	Cured weight, 29-11-34.	Bundled weight, 14-12-34.
14	901	356	370
Average	64·4	25·4	26·4

Considered "dry" on 13-11-34.

Drying time—5 days.

B

No. of Hides.	Green weight, 22-11-34.	Cured weight, 12-12-34.	Bundled weight, 14-12-34.
6	450	170	179
Average	75	28·3	29·8

Considered "dry" on 3-12-34. Had several showers of rain on them.

Drying time—11 days.

Group 5. Sun-Drying Method Recommended by Imperial Institute

A

No. of Hides.	Green weight, 8-11-34.	Cured weight, 29-11-34.	Bundled weight, 14-12-34.
14	924	333	387
Average	66	23·8	27·6

Considered "dry" on 13-11-34.

Drying time—5 days.

B

No. of Hides.	Green weight, 22-11-34.	Cured weight, 12-12-34.	Bundled weight, 14-12-34.
6	453	162	180
Average	75·5	27	30

Considered "dry" on 1-12-34. Had several showers of rain on them.

Drying time—9 days.

Group 6. Sun-Dried over Poles

A

No. of Hides.	Green weight, 8-11-34.	Cured weight, 29-11-34.	Bundled weight, 14-12-34.
15	989	380	411
Average	65·9	25·3	27·4

Considered "dry" on 13-11-34.

Drying time—5 days.

B

No. of Hides.	Green weight, 22-11-34.	Cured weight, 12-12-34.	Bundled weight, 14-12-34.
6	412	159	168
Average	68·7	26·5	28

Considered "dry" on 3-12-34. Had several showers of rain on them.

Drying time—11 days.

APPENDIX C

REPORT BY THE CHAIRMAN AND SECRETARY OF THE COMMITTEE ON THEIR INSPECTION OF THE RAW HIDES

The hides in the raw state were inspected by us at the Imperial Institute.

The Group 1 hides were bundled in pairs. The hides

had been placed hair side to hair side and bundled flesh out. The hides smelled strongly of putrefaction. When unfolded there was no obvious signs of hair slip ; a detailed examination was not made on account of the highly disagreeable odour.

The Group 2 hides appeared in good condition and stood out from the other dry classes by being almost free from insects.

The hides in Groups 3 to 6 were, on the whole, in good condition and there was little to choose between the groups. The hides were clean and appeared to have been well flayed, but had been badly packed for transport. They were folded over hair side in and very little, if any, naphthalene or other insectifuge had been used. They were fairly heavily infested with grease beetles and larvæ, which had caused some damage.

The separate lots of hides had been corded. Detailed reports on Groups 1 to 6, A and B, are given below. A and B represent hides cured in dry and showery weather respectively.

Group 1. *A and B. Pitted.*—14 and 6 hides respectively. In wet-salted condition. Very smelly. Hair and flesh did not appear to be in bad condition.

Group 2. *A and B. Dry-salted.*—14 and 6 hides respectively. Appear to be in good condition. Very few insects.

Group 3. *A. Shade-dried.*—14 hides. Hair bright and clean and tight. Some fleshes very dark, though all clean. All hides show a double pole mark of two parallel ridges. Some hides badly damaged by insects.

Group 3. *B.*—6 hides. Like Group 3.A.

Group 4. *A. Sun-dried on ground.*—14 hides. Hair bright and clean and tight. Flesh in good condition. Hides somewhat wrinkled and puckered. The hides unfold more easily than those of Groups 3 and 5. Insect damage present.

Group 4. *B.*—6 hides. Like Group 4.A.

Group 5. *A. Sun-drying Method Recommended by the Imperial Institute.*—14 hides. Hair clean and bright and tight. Flesh in good condition, a little parchmenty in places. Insect damage present.

Group 5.*B*.—6 hides. Like 5.A, but flesh in rather better condition. Except for insect damage hides are in first-class condition.

Group 6. *A*. *Sun-dried on Poles*.—15 hides. Hair bright, clean and tight. Flesh clean, but some hides show parchmenty areas. All hides show the double pole mark. The hides unfold fairly easily. Insect damage present.

Group 6.*B*.—6 hides. Like 6.A. Flesh in good condition but dark-looking and parchmenty.

(*Sgd.*) D. JORDAN LLOYD.
J. R. FURLONG.

April 12, 1935.

APPENDIX D

REPORT BY MR. H. W. CHADWICK ON RAW HIDES

Group 1. *Pitted*.—

(*a*) 7 Bundles, 14 hides weighing 834 lb.

(*b*) 3 Bundles, 6 hides weighing 378 lb.

Wet, very little salt, snipe heads, short shanks, well flayed for Rhodesians, horn scratched, dry condition, part rather fleshy. The *b* hides are a little loose on the hair.

Group 2. *Dry-salted*.—

(*a*) 1 Bale, 14 hides weighing 493 lb.

(*b*) 1 Bale, 6 hides weighing 222 lb.

Clean, dry-salted cure, rather heavy cure, horn scratched, a few with brands, somewhat scored in flaying, short shanks, a few with light heads. I see no difference in value between the *a* and the *b*.

Group 3. *Shade-dried*.—

(*a*) 1 Bale, 14 hides weighing 392 lb.

Rather harsh dry, light cheeks, pointed heads, short shanks.

(*b*) 1 Bale, 6 hides weighing 168 lb.

Similar, dried in rainy weather.

Group 4. *Sun-dried on Ground*.—

(*a*) 1 Bale, 14 hides weighing 370 lb.

Unstretched, flesh sides up, slightly contracted but generally well flayed, similar trim, do not look so attractive as the stretched hides, but will probably turn out as well.

(*b*) 1 Bale, 6 hides weighing 179 lb.

Similar, except that there are more brands in the butts.

Group 5. *Sun-drying Method Recommended by Imperial Institute.*—

(*a*) 1 Bale, 14 hides weighing 387 lb.

Similar trim, well flayed, few scored, generally free of cuts.

(*b*) 1 Bale, 6 hides weighing 180 lb.

Look just as attractive and in my opinion should give just as good results as *a* selection.

Group 6. *Sun-dried over Poles.*—

(*a*) 1 Bale, 15 hides weighing 411 lb.

Wide stretched, a few holed or branded, some scratched.

(*b*) 1 Bale, 6 hides weighing 168 lb.

Here again the hides look just as attractive as those in *a* and I doubt if results will be any inferior.

Practically no naphthalene was apparent on inspection of the hides and if any was put in at the time of shipment it must have fallen out during transit, as the hides were very loosely packed. In consequence most of the hides have become damaged by worm and their value depreciated by about 10 per cent.

I think that shippers should be advised to trim the heads before shipment and use a plentiful supply of naphthalene.

The hides also contain rather too much fat, which could be quite easily removed before shipment.

In a general way the quality is much superior to the usual shipments of Rhodesian hides and a ready market could be found for these hides in this country if the quality of this sample shipment could be maintained.

(*Sgd.*) HAROLD W. CHADWICK.

April 11, 1935.

APPENDIX E

REPORT BY THE PENKETH TANNING CO., LTD., ON RAW HIDES AND ON LIMED PELTS

A—Cured in Dry Weather.

B—Cured in Showery Weather.

Experiment.	No. of hides.	Weight of raw hide.		Weight of pelt.	Pelt Percentage Gain.	
		In Southern Rhodesia.	On arrival at Penketh.		On Southern Rhodesian weight.	On Penketh weight.
		lb.	lb.	lb.		
1.A. Pitted . .	14	834	694	964	15·5	38·7
1.B. do. .	6	378	322	450	19·0	39·7
2.A. Dry-salted .	14	493	456	1,006	104·0	120·6
2.B. do. .	6	222	218	453	104·0	107·8
3.A. Shade-dried .	14	392	380	1,019	159·9	171·8
3.B. do. .	6	168	162	443	163·6	173·4
4.A. Sun-dried on ground .	14	370	366	978	164·3	167·2
4.B. do. .	6	179	175	457	155·3	161·1
5.A. Sun-drying method recommended by Imperial Institute .	14	387	381	1,008	160·4	164·5
5.B. do. .	6	180	177	465	158·3	162·7
6.A. Sun-dried on poles . .	15	411	399	1,071	160·5	168·4
6.B. do. .	6	168	162	454	170·2	180·2

Experiment.	Report on Hides in dry state.	Report on Pelts.
1.A. Pitted	Rather wet on the hair side, although no signs of hair slipping. Many of the hides show signs of red heat on the flesh side and were rather slimy in these places. There did not seem to be much salt on the flesh side. Perhaps more would be an advantage. Bright hair.	Exceptionally sound lot of hides. No sign of putrefaction whatever. Excellent lot for Rhodesian hides. Good flay; fairly plump hides.
1.B. do.	Exactly similar to 1.A. Could see no difference at all.	No difference at all from 1.A. Perfectly sound pelt. No signs of any putrefaction; well flayed and well grown for type.
2.A. Dry-salted	Very clean lot, white flesh. Heavy D/S cure; look very nice and sound. Should work well. Bright hair.	A perfect cure; not a sign of putrefaction anywhere; just like a W/S pelt.

Experiment.	Report on Hides in dry state.	Report on Pelts.
2.B. Dry-salted	Cannot see any difference at all between this cure and 2.A.	Very fine lot; perfectly sound. No sign of putrefaction. Just like a W/S pelt.
3.A. Shade-dried	Very clean looking flesh, good condition. Part of one hide appeared to have been wet at some time and not dried out again properly. May go rotten. The marks of the poles could be plainly seen down the backbone. Bright hair.	Quite a sound lot on the whole; twelve hides being perfectly sound, one hide very slightly putrefied, only grain surface about 2 ins. square near tail. The other hide was very badly damaged, blistered and rotten. Most probably this was the hide reported on in the dry state.
3.B. do.	Very similar to 3.A. Perhaps the mark of the poles was more apparent.	Fairly sound on the whole, very white in patches on the flesh side where fat had gone rancid and caused slight putrefaction. *Four* hides were quite sound. *One* slightly putrefied round tail and on hip on grain side, exactly where fat had been left on in excess. *One* slightly putrefied in small spots only, due to fat being left on flesh side in excess. Badly cracked all along the pole mark.
4.A. Sun-dried on ground	Exceptionally clean looking lot; appear very good, with bright hair. Very much cleaner than the Rhodesians imported in the ordinary way.	* Exceptionally poor lot, practically all badly putrefied from flesh side in large patches—absolutely useless. Very poor method of drying.
4.B. do.	Very nice, clean looking lot, both hair and flesh; good condition. No different to 4.A.	Very badly damaged lot; useless. Blistered and rotten, absolutely falling to pieces. One hide was sound, the other five badly damaged all over.
5.A. Sun-drying method recommended by Imperial Institute.	Very clean flesh and hair, good condition. Bright lot. Different shape to the other hides owing to being suspended.	A perfect cure, not a sign of putrefaction anywhere. Beautiful pelt, equal to the D/S. A marvellous lot of hides.
5.B. do.	Could see no difference between these and 5.A. Good condition, quite a nice looking lot.	Very sound lot of hides, with the exception of one which was stained in places and appeared to have been lying in water, causing slight putrefaction on the grain in spots; otherwise quite good.

Experiment.	Report on Hides in dry state.	Report on Pelts.
6.A. Sun-dried on poles	Beautifully clean looking lot; bright hair and flesh; good condition. The pole marks were very visible down the back-bone.	Quite a sound cure, 13 hides being absolutely sound, the other two only very slightly putrefied, one along the pole mark, and the other on the britch. 50 per cent. of the hides were very badly cracked all along the back-bone, a very bad fault. The flesh appeared white in spots, as though the fat had gone rancid; no apparent damage.
6.B. do.	Appear very nice. Could see the pole-marks down the back-bone very plainly. Very dry condition; bright hair, clean flesh.	Quite a sound lot of pelt, one hide very slightly putrefied on grain, only surface deep, about 2 ins. square. One hide badly cracked down the back-bone. Some hides appeared rather white on flesh side as though the fat had gone rancid.

* *The following is a detailed report on the* 14 *individual hides of* 4.*A*.:

1. Slightly putrefied all over from flesh side.
2. Very badly blistered all over butt from flesh side.
3. Very badly putrefied all over butt, flesh side.
4. Badly putrefied all over butt, from flesh side.
5. Do. do. do. do.
6. Do. do. do. do.
7. Do. do. do. do.
8. Slightly putrefied from flesh side.
9. Badly putrefied from flesh side all over.
10. Very slightly putrefied round tail.
11. Perfectly sound.
12. Slightly putrefied on flesh side of butt.
13. Badly putrefied on butt, flesh side.
14. Badly putrefied on butt, flesh side.

May 24, 1935.

APPENDIX F

REPORT BY THE CHAIRMAN AND THE PENKETH TANNING CO., LTD., ON THE HIDES IN THE LEATHER STATE

The hides had been vegetable tanned and finished as sole leather.

1. *A*. *Pitted.*—Quite sound pelt, but the grain appeared rather tender as 70 per cent. had the grain rubbed off in very small patches by the machine in the finishing process, showing that the grain was inclined to be weak.

1.*B*. *Pitted.*—Quite sound; no apparent tender grain.

2.*A*. *Dry-salted.*—Excellent; absolutely sound; no signs of putrefaction anywhere.

2.*B*. *Dry-salted.*—Excellent, with the exception of one hide, which had three small patches of tender grain about as big as a penny, rubbed off by the machine.

3.*A*. *Shade-dried.*—Perfectly sound lot, with the exception of one hide, which was badly blistered. The grain had been attacked by worms and eaten on 65 per cent. in very small holes, also some grain damage, probably due to worms.

3.*B*. *Shade-dried.*—Quite a sound cure, but there were white patches on most bends as though putrefaction was just starting. Three hides had slightly damaged grain just on the surface, as though tender.

4.*A*. *Sun-dried on Ground.*—One hide turned out perfectly sound; two hides were only slightly putrefied on the flesh side, although they showed signs of tender grain. The remainder were absolutely useless, badly blistered and damaged, practically all from the flesh side. Very bad method of curing.

4.*B*. *Sun-dried on Ground.*—One hide sound, but tender grain and worm eaten; the remainder very badly damaged by blister, all from flesh side. Very poor method of curing.

5.*A*. *Sun-drying Method Recommended by the Imperial Institute.*—Excellent, perfectly sound lot of hides; no signs of putrefaction; one or two bends slightly damaged by worms, which had eaten off the grain layer in small patches.

5.*B*. *Sun-drying Method Recommended by the Imperial Institute.*—Excellent lot with the exception of one hide, which had two small spots of damaged grain; otherwise very sound.

6.*A*. *Sun-dried on Poles.*—Quite a sound cure; some hides slightly worm eaten in patches on the grain side; 50 per cent. of the hides were cracked down the back-bone due to being over a pole; there were also signs of putrefaction as well.

6.*B*. *Sun-dried on Poles.*—Quite sound with the exception of one hide, which was very slightly grain damaged in one spot about 2 ins. square. Three hides showed the pole mark.

(*Sgd.*) D. JORDAN LLOYD.
R. WITHINSHAW.

November 29, 1935.

APPENDIX G

REPORT ON THE MICROSCOPICAL EXAMINATION OF THE LEATHER PREPARED BY THE PENKETH TANNING CO., LTD.

By THE BRITISH LEATHER MANUFACTURERS' RESEARCH ASSOCIATION

SUMMARY

Photomicrographs were prepared of the corium of the leather, the samples for this purpose being cut from the sound parts of the tanned hides.

The examination showed that all the methods of curing employed in these experiments yielded leather of good micro-structure, apart from areas of local damage.

The structure of the dry hide leathers is particularly good, and there is but little difference to record between the leathers from the various curing methods. The leather from Group 5 (Method of Sun-drying recommended by the Imperial Institute) was slightly superior in fibre structure to the others, that from Group 6 (Method of Sun-drying over Poles) being the next best.

On the whole the showery weather hides (Series B) gave slightly better results as a group than the dry weather hides (Series A). This result is of interest, and may possibly be accounted for by the slower drying which took place in the case of Series B. The difference between the two series was, however, very slight, and further work on the effect of various rates of drying would be desirable before any definite opinion could be given on this point.

January 11, 1936.

APPENDIX H

METEOROLOGICAL DATA OF THE CURING PERIODS

I. PERIOD DURING WHICH LOTS A (DRY WEATHER) WERE PREPARED

(November 8 to 13, 1934)

	Temperature. °F. *Max.*	*Min.*	*Daily Mean.*	Sunshine. *Hours.*	Rainfall.	Humidity. *Per cent.*
Nov. 8	90	62	77	11·7	Negligible	30
„ 9	83	64	73	12·5		48
„ 10	87	62	73	11·4		61
„ 11	91	63	78	9·9		37
„ 12	85	65	75	4·5		51
„ 13	85	62	73	6·2		84
Average	86·83	63·0	74·83	9·37		51·83

II. PERIOD DURING WHICH LOTS B (SHOWERY WEATHER) WERE PREPARED
(November 22 to December 3, 1934)

	Temperature. °F. Max.	Min.	Daily Mean.	Sunshine. Hours.	Rainfall.	Humidity. Per cent.
Nov. 22	74	63	67	1·2	Light shower	88
„ 23	78	64	68	7·4		83
„ 24	67	59	62	1·1	Heavy shower	92
„ 25	76	59	66	4·6		78
„ 26	84	59	65	12·9		66
„ 27	79	60	69	12·2		56
„ 28	74	59	64	7·6	Heavy shower	83
„ 29	81	57	69	10·6		63
„ 30	84	60	73	12·3		57
Dec. 1	86	61	74	12·2		46
„ 2	88	63	76	12·4		53
„ 3	81	65	71	4·0		56
Average	79·33	60·75	68·67	8·20		68·42

ARTICLES

SOME OBSERVATIONS ON THE METHODS OF MAKING CLARIFIED BUTTER (GHEE) WITH SOME NOTES ON A NEW METHOD

By M. H. French, M.A., Dip. Agric. (Cantab.)

Biochemist, Department of Veterinary Science and Animal Husbandry, Tanganyika Territory

In hot countries milk and butter cannot be stored for any length of time. Also, in most of the dry, hot regions of the world, the yield of milk fluctuates considerably with the season of the year. The inhabitants of such semi-arid regions were forced to evolve a method of storing dairy products, prepared during the rainy period, for use during the drought period when no surplus milk can be obtained. Such a process was developed in India and has since spread to other sub-tropical countries. The original Hindustani name for this product was "ghi," and this term, written as "ghee," has been retained by most producing and marketing countries.

The principle underlying the production of ghee is the preparation, in a solid form, of milk fat free from water, proteins, and salts, *i.e.* "clarified butter," as it is known in Western civilisation. The methods in vogue for producing this article vary greatly, from the crude native methods to

the refined method of the European chef who prepares his "clarified butter" from high-quality fresh butter.

Theoretically the milk of any animal species could be used in the preparation of clarified butter or ghee, but in practice it is made chiefly from the milk of cows and buffaloes, though occasionally it is also derived from sheep and goat milk.

Ghee has been made in the East and particularly in India for centuries, but in India, which is still the largest ghee-producing country, it is nearly always adulterated. In fact most of the literature on this product is concerned with the detection of, or the legislation against, the adulteration of this article and very little has been written on its preparation. In India both animal and vegetable fats are used as adulterants, and many flavouring materials are also added. The quality of Indian ghee varies considerably, but to the average European who has lived in India the word "ghee" conjures up a picture of a dirty, oily fat with an offensive rancid smell. The term "clarified butter," on the other hand, makes one think of an attractive, yellow, wholesome article of food. Although both of these terms refer to the same article (butter fat) it speaks much for their methods of preparation that few people would connect the two products.

Ghee is made in most of the African Territories, but the native-made article is just as offensive in appearance, smell, and taste as is the average Indian product.

In Tanganyika Territory the Government have been fostering the production on a large scale of a good quality article capable of attracting a market in Western Europe. The efforts have been so successful that the present article has been written. It is proposed here to restrict the term "ghee" to the unattractive, native-made article, and to use the term "clarified butter" for the very good quality food now being produced under Government supervision.

In all the older methods of making ghee a large percentage of the water, protein and salts of the milk is removed in the first part of the operation by turning the milk fat into butter. In the second step the butter is heated and the remaining water is boiled off as steam. The protein is coagulated, precipitated and filtered off.

In the country districts of India, one still finds ghee being prepared by the old historic methods. Immediately after

milking, the milk may be sterilised by heating it for an hour or more, but more often no sterilisation of this kind is carried out. The milk is put into a large earthen or brass jar and inoculated with a starter of sour milk. When the milk has curdled it is diluted with warm water and churned with a split bamboo or crude wooden vanes, which are twirled by hand, until the butter forms. The granules of butter are skimmed off the surface and allowed to stand for some time for excess water to drain away. During this interval much rancidity develops. The butter is then clarified by heating in an earthen or brass pot. After all the steam has boiled off the mixture is allowed to stand for the protein to sediment and then the liquid fat is poured off into containers.

In East Africa this is still the method used by many natives. The preliminary souring of the milk is done in gourds and churning consists of shaking the contents of the gourd until butter begins to form. The butter is collected and mixed with the butter from churning during several previous days. It is stored in an earthen pot and whilst standing gets thoroughly contaminated with dirt and insects. Boiling into ghee is done on a smoky wood fire when enough butter has accumulated to make this operation worth while. Native-made ghee prepared in this way is a white, tallowy, semi-liquid fat, smelling offensively and full of insects and dirt.

Kothavala and Cox [1] have recently pointed out the inefficiency of these old methods of manufacture when compared with modern procedures.

The first big step towards improving the method of preparation was the introduction of the separator and churn. The improved method which is being used in most countries employs both these instruments. The milk is separated as soon as possible after milking and the cream allowed to ripen, with or without the addition of a starter. The ripened cream is churned and the butter thoroughly washed, and after standing overnight is boiled into ghee. This method yields a very good article when carried out under European supervision.

During the past year much time has been spent in trying to improve the quality of the clarified butter produced by the Native Authority creameries. The natives and Indians, unless supervised by Europeans, produce a very inferior ghee

even when using a separator and churn. No effort is made to keep the utensils clean and cream is often left for days until very rancid and mouldy before it is churned. Also, a long interval elapses between churning the butter and boiling it into ghee.

In Tanganyika Territory the native milks into gourds which are not very clean and as a result the milk rapidly turns sour. To overcome this difficulty milk tins, which are sterilised each day at the creameries, are supplied to the native for him to milk into directly and bring his milk to the creamery. It has been found, however, that the native still milks into his gourd and subsequently pours the contaminated milk into his clean tin. Native milk arriving at a creamery in East Africa may, therefore, be expected to and usually does, show a certain degree of rancidity. Cream separated from such milk will likewise possess a small amount of rancidity.

Work done during the last year has shown that, in spite of native milk having been well seeded with a very mixed bacterial population before it reaches the creamery, clarified butter of the highest quality can be produced from it. Laboratory trials have proved that the clarified butter made from locally-purchased native milk was just as good as that made from milk produced under the clean conditions of a Government dairy. One properly managed creamery has also dispensed with the milk tins usually supplied to the natives. The milk is brought to the creamery in the native gourds and no drop in quality has resulted.

The cream from native-produced milk possesses a very mixed bacterial content and probably not the types most suitable for producing the right type of acidity in the cream, or the finest flavour in the butter. Theoretically it is necessary to sterilise the cream and then seed it again with a starter containing the right bacteria. In practice this means extra work for the creamery staff and it would be almost impossible to keep a starter free from contamination with the undesirable bacteria which must be floating about in the air of a creamery in a hot district.

Experience in the creameries has now shown that cream ripens very quickly without the addition of a starter and possesses the right acidity for quick churning in from 12 to

18 hours. The addition of a butter-milk starter is very liable to cause over-ripeness of the cream and results in more difficult churning and a poorer quality of butter.

Much depends on the butter being churned correctly. In Tanganyika Territory metal rotary churns have been adopted as the most suitable. They are very easy to keep clean, even when this is left to a native, and require no attention during the close season. The instructions of the makers should be followed very carefully, though the amount of washing that has been found necessary is much more than they recommend. Six washings of the butter is now the recognised procedure in the creameries. Over-churning the butter must be strictly avoided, because if this happens the butter loses its grain and becomes lumpy and is then most difficult to wash properly.

Tests made on fresh butter correctly churned and well washed have shown that it possesses no trace of rancidity. On the other hand, samples of good butter that have not been washed sufficiently show a slight rancidity. All butter that has been over-churned shows a rancid reaction and it is practically impossible to free completely such butter from the butter-milk.

In the past it has been the practice of the creameries to churn the butter one day and then allow it to drain until the following day before boiling it into ghee. It has been shown that even good, well-washed butter, when allowed to stand 24 to 30 hours in a native creamery, develops a definite rancidity in the surface layers. The extent to which the butter has become rancid depends upon the quality. Poor, insufficiently-washed butter gives a rancid reaction even from the interior of the lump. It has now been adopted as a standard routine that all butter must be boiled into clarified butter on the day of churning.

During the boiling of the butter, the proteins are precipitated and the water is removed in the form of steam. The lower molecular fatty acids produced by the lipolytic action of micro-organisms are slightly soluble in water and distil off in the steam. This means that butters possessing but a slight rancidity when put on to boil lose all these volatile acids during clarification. On the other hand, it has been shown that in those butters which have developed a pronounced

rancidity the usual period of boiling is not sufficient to remove all the volatile products and the clarified butter may show a small amount of rancidity. Even this can be overcome, as happens in Indian-made ghee, by boiling for a longer period. However, this over-boiling results in an inferior product, which does not possess the solidity, grain, colour or taste of the good clarified butter from the creameries.

Therefore, for the production of good clarified butter from ordinary butter the following points are of particular importance :—

(*a*) The cream should ripen for as short a period as possible. Usually starters will not be found necessary in hot countries.

(*b*) The butter must be churned correctly and then very thoroughly washed.

(*c*) Butter should be clarified as soon as possible after churning.

(*d*) The butter must be correctly boiled.

The boiling of the butter is not such an easy procedure as one would at first imagine. Boiling must take place steadily and be neither too slow nor too fast. Many trials have been made by the Veterinary Staff to find the best type of stove for boiling. Wood is the fuel used in all creameries and much difficulty was at first experienced owing to the wood being wet. If boiling is to be uniform, the wood must be quite dry. Charcoal is used as the fuel in some countries, but it seems unnecessarily expensive.

Boiling takes place much more uniformly if the top of the stove is recessed to take the boiling pan. The flames of the fire should never play directly on to the pan, which should rest on a metal surface covering the fire. Great care is necessary to see that the smoke is led away properly, because clarified butter readily acquires a smoky taint. The boiling pan should be of metal and have as large a diameter as possible, because in this way heating takes place much quicker than in a deep, small-bottomed pot.

Clarifying the butter is regarded as an art and it is quite impossible to lay down rules as to the correct period necessary if boiling is to proceed at the optimum rate. There are so many factors involved that the time is never constant in any one creamery. Thus 56 lb. of l may take anything from 20 to 90 minutes to clarif ctly. Further, it is

impossible to say that boiling should be continued until a definite temperature is reached. I have found that the final temperature of the clarified butter when ready to be removed from the fire may vary between 110°C. and 140°C., but usually averages about 128°C. for many boilings both in the laboratory and in the creameries. When using good-quality butter, I recommend that the boiling should be as brisk as possible without running the risk of the molten butter foaming out of the boiling pan.

As examples of the variations in times of boiling, Table I shows the protein, moisture, and temperature changes of the clarifying butter as the boiling period is lengthened :

TABLE I

Changes in the Composition of Butter during Clarification

Sample No.	First Test.				Second Test.			
	Interval of time.	Temperature.	Moisture.	Protein.	Interval of time.	Temperature.	Moisture.	Protein.
	Mins.	°C.	*Per cent.*	*Per cent.*	*Mins.*	°C.	*Per cent.*	*Per cent.*
No. 1 (Butter)	0	24	18·52	0·92	0	28	14·82	0·58
No. 2	5	94	14·53	0·88	20	94	13·2	0·35
No. 3	10	94	9·95	0·55	30	94	10·5	0·29
No. 4	18	96	1·07	0·42	40	98	3·0	0·17
No. 5	23	108	0·39	0·36	50	114	0·2	0·09
No. 6 (Clarified Butter)	28	130	0·01	0·03	58	124	0·00	0·02

The first test took less than half the time required by the second, yet the final product is just as good.

Rules can be laid down whereby the operator can judge correctly the point at which the butter is clarified and ready to leave the fire. The physical changes taking place are as follows :

(*a*) Butter commences to melt at 30°C. and by the time the temperature has risen to 64°C. all the butter will have melted.

(*b*) A foam forms on the surface and this increases in volume until a temperature of 94°C. is reached.

(*c*) The liquid butter starts to simmer at 94 to 96°C. and the temperature remains about constant until nearly all the water has boiled off.

(*d*) The contents of the boiling pan become much thicker and resemble thin custard. As the last of the water is boiling

off at 98°C. bubbles begin to break with sufficient violence to cause a small amount of spitting.

(*e*) The curd begins to form into lumps as the temperature approaches 110°C. Many large bubbles break on the surface at this stage and much of the protein precipitate is carried up and forms a scum on the surface.

(*f*) The protein particles contract as the temperature gets near to 120°C. and sink to the bottom of the pan. The scum disappears from the surface and the general appearance is that of a clear, amber-coloured liquid with white protein particles in suspension near the bottom of the pan. If boiling is stopped at this point the ghee possesses a peculiar smell which is aptly termed "unripe" by the natives.

(*g*) As the temperature rises above 120°C. the large bubbles are gradually replaced by smaller ones, until suddenly a foam of small bubbles is formed closely resembling in appearance "soap-suds." This foam rises rapidly and at this point the pan must be quickly removed from the fire.

A method of checking if the correct point has been reached is to observe the colour of the protein sediment as soon as the bubbles disappear. If these particles are lighter than the supernatant butter fat then boiling has been stopped a little too soon. These particles take on a slightly darker colour than the liquid if clarification is complete. When the fat has been overboiled the protein sediment becomes charred and black.

When correctly boiled the clarified butter is filtered into containers.

During boiling it is very necessary that the contents of the pan are stirred gently and continuously, otherwise charring will take place and the quality be ruined. When the protein curd begins to sediment it is essential that vigorous stirring be avoided, otherwise the clarified butter will be cloudy in appearance due to the fine protein suspension which passes through the strainers.

Some authorities advise that the scum should be skimmed off during the clarification of butter. This point has been investigated and was found not to be necessary. All the protein removed by this skimming would be precipitated in any case, whereas its removal means extra work and boiling for the operator.

If overboiled the clarified butter loses its attractive colour and takes on a dirty white hue. It smells charred and tallowy and loses its grain, whilst in many cases it remains liquid. When kept simmering for a long time at a moderate temperature an oily product results, which never solidifies completely.

Work on the solidification of clarified butter has shown that small lots solidify much more quickly and uniformly than do large bulks. When filling large containers of 28 lb. capacity, or over, it is advisable only to fill the tin one-third full at a time. The first lot being allowed to solidify completely before subsequent lots are added. Very hot fat should not be poured on already solidified clarified butter, but should only be added when nearly cold.

It has also been shown that the containers must not be sealed whilst the fat is still hot, otherwise a vacuum is produced which considerably delays solidification.

Clarified butter should possess an attractive yellow colour and be either free from smell or possess a faint toffee odour. At all ordinary temperatures it should be solid, with a well-marked granular consistency. Normally it should have a sweet taste, free from rancidity, and in the best samples should resemble butter. When rubbed on the palm of the hand it should readily liquify. As clarified butter is free from protein and water it does not become mouldy or decomposed by the activity of micro-organisms. If well stored it will keep indefinitely.

There are certain deteriorating chemical changes which may take place in clarified butter. I refer to the autoxidation of the butter fat. This change is accelerated considerably by exposure to ultra-violet light, free contact with air, high acidity of the cream before conversion and is catalysed by the presence of certain metallic elements (iron and copper) [2]. The autoxidation is accompanied by bleaching and the development of a tallowy smell and taste. Such changes are detected even in the early stages by the Kreis test; all clarified butter prepared under veterinary supervision in the Territory is subjected to this test and only samples giving a negative reaction passed. Although autoxidation readily occurs under certain conditions it does not take place if the fat is stored in full, sealed containers in the dark.

In an experiment at the laboratory, a sample of clarified butter was divided into seven lots and subjected to seven different treatments for a period of six weeks with the results shown in Table II. Each small sample was contained in a glass jar, which was completely filled to the stopper :—

TABLE II

Deterioration of Clarified Butter by Autoxidation

Treatment.	Effect on colour.	Effect on taste.	Development of positive Kreis test.
Sealed with wax and exposed to sunlight.	nil	nil	nil
Loosely stoppered and exposed to sunlight.	Slight bleaching round stopper.	Tallowy only round stopper.	Positive in top layers but negative beneath.
Plugged with cotton wool and exposed to sunlight.	Completely bleached.	Tallowy.	Strongly positive throughout even after diluting 1 in 20.
Plugged with cotton wool and kept in the dark at 0° C.	nil	nil	Very faint trace in surface layer.
Plugged with cotton wool and kept in the dark at 24° C.	nil	Tallowy only in surface layers.	Trace in surface layers only.
Sealed with wax and kept in the dark at 24° C.	nil	nil	nil
Loosely stoppered and kept in the dark at 24° C.	nil	nil	Very faint trace round the stopper.

This experiment demonstrates how the Kreis test detects changes not yet apparent to the taste or in the appearance of the clarified butter.

Further, the results show that, in the absence of sunlight, autoxidation proceeds very slowly, even though the fat is exposed to the air (oxygen). In the absence of air, even sunlight produces little or no change. Thus, if clarified butter is kept in filled metal containers it can be stored for very long periods. When the containers are opened, they should be kept in a dark spot or protected from sunlight. In the small samples tested in the laboratory a month was necessary for complete bleaching of a 30 gm. sample of clarified butter, even when continuously exposed to sunlight and air, so that under ordinary conditions a housewife need not fear that a large tin of clarified butter will deteriorate before she has used it up completely.

A New Method of Making Clarified Butter

In the older methods and in the method used in most countries to-day butter is prepared and clarified later. It has been pointed out above that the ripening of cream cannot be controlled very easily owing to the risk of contamination by undesirable types of bacteria. These unwanted bacteria give rise to many side products which though present in minute amounts detract from the flavour of the butter produced. Also over-ripening of the cream with a large production of acid results in a butter of poor-keeping qualities. Further, even when clarified, butter from highly acid cream is more liable to autoxidation than if made from cream of the right acidity.

Also the butter has to be churned correctly otherwise efficient washing is impossible and the resulting clarified butter possesses some of the rancidity developed during the ripening of the cream.

If there is to be any large production of clarified butter much of the work will have to be left to natives. This means that the less skilled the work, the more capable will the native be to carry it out. The making and washing of butter is a skilled business, but turning a separator is mechanical. Clarifying butter has been regarded as an art, though, as shown earlier, if certain observations are made then it loses its right to be regarded as such.

In any case the boiling process cannot be eliminated.

In an effort to simplify the production of clarified butter so that a first-class article could always be turned out, the direct boiling of cream was tried. Cream contains very much more protein and water than butter and the only reason for making butter as an intermediate step in all the older processes is to reduce the quantities of these before boiling.

As was to be expected, both in the laboratory and creamery tests on the boiling of fresh cream, the direct boiling was not a success.

The large amount of protein present caused some to stick to the bottom of the pan and char, thus reducing the quality of the final product.

An attempt was then made to reduce the amount of protein present by washing the cream with water. This was

accomplished by mixing the cream with water so as to make a volume equal to half that of the original milk separated. This cream emulsion was then reseparated. By this means the protein content was reduced to about the same percentage as is found in butter. Laboratory trials showed that this washed cream could be clarified without difficulty. Further trials on this method have been made on the Government dairy farm and on a large scale in one creamery. All the reports show that this method is working perfectly satisfactorily under creamery conditions.

In this washed cream method the small amount of rancidity present in the freshly-separated cream from native milk is partially removed by washing. The small amount left in the washed cream disappears during boiling. The result is that the product can be guaranteed absolutely free from rancidity. Further, since it is made from fresh cream its keeping qualities are better than that from butter produced from acid cream.

By general consent this clarified butter is graded as the best turned out in the Territory. It has a good colour, is always solid below 30°C. and in my opinion is better than the best Indian-made article. Its taste resembles butter very closely. The Vitamin A content of this fresh cream clarified butter is much (3 times) higher than in the normal creamery product.

The loss of butter fat in reseparating the milk will not be more than is lost in the butter-milk, the butter left in the churn and on the butter-working table. Yields from the creamery confirm the small scale laboratory tests that there is no appreciable difference in yield of clarified butter between the standard and the new methods.

The washing of the cream and reseparating is absolutely mechanical and eliminates the need for an intelligent butter maker. This means that there is a saving on the utensils and skilled labour whilst a better product is turned out.

Summary

An outline of the old and improved methods of making clarified butter has been given with notes on the quality of the product.

Certain improvements in the method of preparation from butter have been suggested as the result of recent work in

Tanganyika Territory. These include (*a*) the shortest possible interval of ripening the cream, (*b*) thorough washing of butter and its immediate clarification, (*c*) correct boiling of the butter.

The clarification process has been studied and rules formulated to enable the end point to be judged correctly.

Some factors which affect solidification have been discussed.

A new method of preparation from washed fresh cream has been described. This method is more simple and fool-proof than the butter method. Clarified butter of the best quality is made by this method.

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RECENT DEVELOPMENTS IN GOLD MINING IN TANGANYIKA TERRITORY

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In order to realise the recent expansion of gold mining enterprise in Tanganyika Territory, it will be helpful first to review briefly the conditions since gold mining was first attempted in the Territory some twenty-five years ago. At that time, gold was known to occur in the Mwanza and Musoma districts in the drainage basin of Lake Victoria and in the Mkalama district, including Sekenke. The Lupa Goldfield was not discovered till 1921. Communications were then very imperfect, no motor transport was available and goods and machinery had to be handled over long distances, almost entirely by head porterage, which was both slow and costly.

Early production with restricted plant and capital was interrupted in 1914 and it was not till several years after the War that attempts to reorganise the industry gained any headway. The Lupa Goldfield started as a new alluvial discovery some 14 years ago in a remote, almost uninhabited

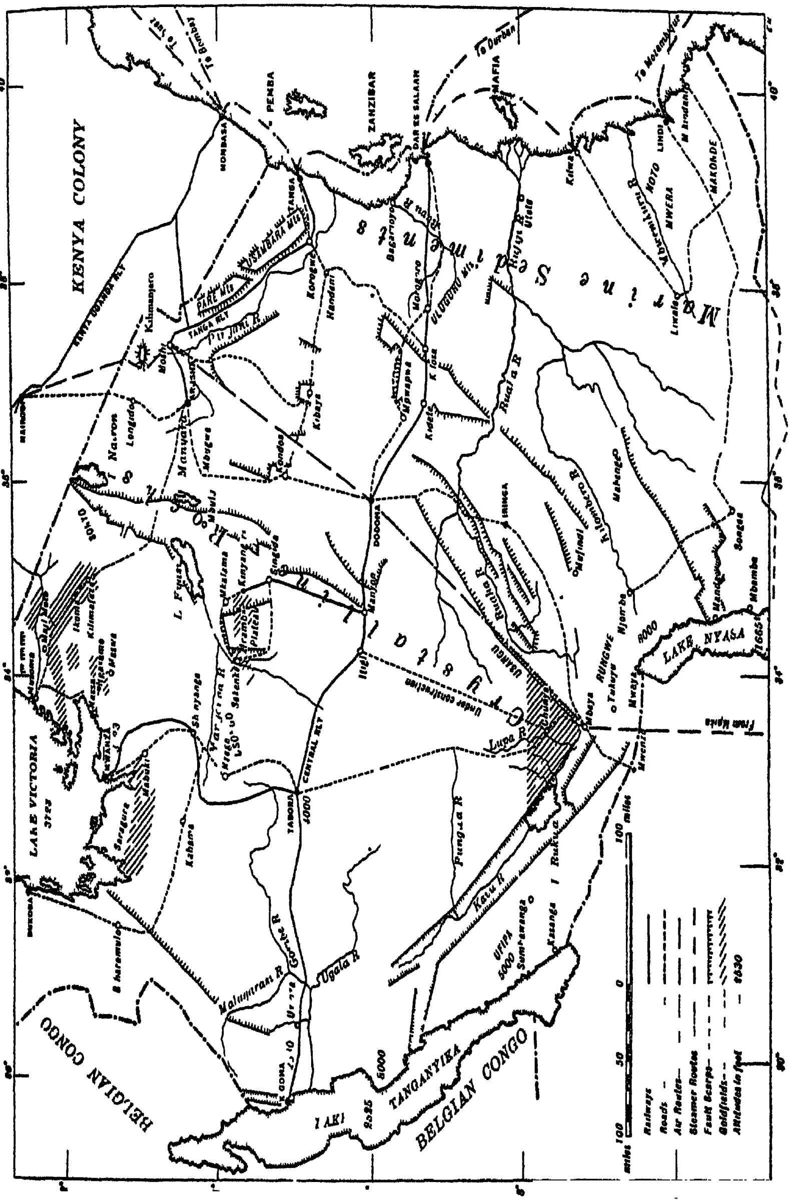

FIG. 1.—SKETCH-MAP OF TANGANYIKA TERRITORY SHOWING GOLDFIELDS

region, unmapped either topographically or geologically and only reached by a most circuitous route of some 450 miles, difficult even under the most favourable dry weather conditions and impassable for many months during the wet season.

In the meantime, during the past ten years, progress was being made which paved the way for the bigger revival, caused by the progressive rise in the value of gold. A Mines Department was established, the rights regarding old German claims were investigated and mining laws and regulations were framed to enable prospecting and production to be resumed. A Geological Survey soon followed (1926) and commenced to pick up the threads of the earlier work of the German geologists, notably Bornhardt, Dantz, Scholz, Kuntz, Koert, Hennig, Reck and others. Laboratory service, including the assay of ores, was added to the Geological Survey work.

Railways were extended, notably to Mwanza and to Kinyangiri via Singida, motor transport and roads developed, and last of all the Imperial Airways arrived with local feeder service and hire facilities, thus speeding-up mail and passenger communication both within the Territory and with the outer world in an astonishing manner.

Gold production has been steadily increasing, as shown by the following figures, which do not yet include the results of the new large-scale operations, which should augment the amount very materially within the next eighteen months.

TANGANYIKA TERRITORY

GOLD PRODUCTION

	Reef.	Alluvial.	Total.	Value.
	oz.	oz.	oz.	£
1923	315	1,010	1,325	4,906
1924	1,171	6,085	7,256	29,235
1925	1,236	9,159	10,395	38,981
1926	1,122	6,961	8,083	30,312
1927	925	9,621	10,536	34,630
1928	2,537	12,383	14,928	54,551
1929	1,347	9,118	10,536	38,630
1930	5,335	7,636	12,971	47,013
1931	7,200	8,000	15,200	58,449
1932	15,038	15,843	30,881	149,864
1933	15,492	24,041	39,533	201,886
1934	22,931	31,771	54,702	291,112

To-day there are four definite goldfields, either with producing mines or with the realisation of such in sight. Their areas are not yet fixed, for their limits are still expanding. These fields from north to south are: the Musoma Goldfield, lying to the east of Lake Victoria; the Mwanza Goldfield, lying to the south-east and south-west of Lake Victoria; the Mkalama Goldfield, which includes Sekenke, situated north of the Central Railway and south of Lake Eyasi; and finally the Lupa Goldfield in the south-west portion of the Territory on the south-eastern side of Lake Rukwa.

The Musoma Goldfield

The Musoma Goldfield extends easterly from the port of Musoma on Lake Victoria for a distance of some sixty miles and south-easterly via Ikoma to Kilimafeza about 120 miles. If we omit the more isolated last-named region, it can be stated that the main producing zone at present embraces a belt of country stretching W.S.W. for about 90 miles, starting in the East Mara region, thence via the mines of Maji Moto, Simba East, Simba West, Buhemba, Lonesome, Blue Ridge, Nyasirori, Kiabakari, to Mrangi. The total area within which gold-bearing formations have been proved amounts to about 3,500 sq. miles. It has recently been mapped geologically by G. M. Stockley and the results of his survey are recorded in *Outline of the Geology of the Musoma District,* issued as Bulletin No. 7 of the Geological Survey of Tanganyika Territory. Two separate coloured geological maps are also available. The geology is by no means simple, because of the variety of formations and igneous rocks. From the point of view of gold occurrences, the most important are the Musoma series, consisting of an ancient group of acid and basic volcanics, schists and banded ironstones, and the Ikorongo series, an overlying sedimentary formation consisting chiefly of conglomerates, grits, argillites and phyllites. Both are intruded by granite and its acid and dioritic differentiates.

The mineralisation is broadly of two kinds, namely, normal auriferous quartz occurrences and pyritic impregnations with little or no reef quartz. Examples of the latter are found at Tarime in the North Mara, Maji Moto, Nyasirori (in part) and Kiabakari. Most of the other occurrences so far opened up consist of quartz reefs. The dominant mineral associated

with the gold is iron pyrites, but some galena and a little arsenical pyrites and copper pyrites also occur. There is, undoubtedly, some secondary enrichment in most of the occurrences in this field, of a residual type in the upper or oxidised portions of the lode and of the reprecipitation character at or near the sulphide zone, at depths of perhaps 60 to 150 ft. As yet there has been no deeper exploration on the field and hence little is known about the conditions of the primary ore shoots.

Production in the past has been in the hands of small workers with limited capital, therefore development in depth has been much restricted. An important step forward, however, has been made by the Tanganyika Diamonds and Gold Development Co., Ltd., in the eastern portion of the field where development on two levels to 150 ft. has given good results and a modern plant for deep mining and ore treatment on a reasonable scale has recently been installed. The production figures for this field for 1933 and 1934 are as follows :—

Mine.	1933.		1934.	
	Ore Treated.	Bullion recovered.	Ore Treated.	Bullion recovered.
	tons.	*oz.*	*tons.*	*oz.*
Mrangi	1,453	1,363	1,370	1,600
Buhemba	2,823	1,411	6,819	3,461
Nyasirori	764	742	821	492
Maji Moto	1,365	734	3,973	585
Negoti	2,956	392	(*a*)	(*a*)
Lonesome	1,075	334	932	282
Nyabogati	475½	175½	(*a*)	(*a*)
Kilima Feza	103	158½	(*a*)	(*a*)
Rohogo	250	139½	586	367
Simba East	150	132	4,800	1,626
Kirege	224	72¼	(*a*)	(*a*)
Blue Ridge	335	70⅓	642	128
Mgendagenda	94	30	(*a*)	(*a*)
Kwigutu	29	17	465	168
Tigiti	3¾	3¾	(*a*)	(*a*)
Karorere	—	—	304	66

(*a*) Information not available.

The Mwanza Goldfield

The existence of gold-bearing formations in this region has been known for many years and gold has been produced from the Ngasamo mine, situated to the south-east of Lake Victoria about 12 miles south of Nassa on Speke Gulf and

some 60 miles by road from Mwanza. This region merits more careful attention. The most important developments, however, have been the new discoveries in the south-west Mwanza region, notably at Saragura, where Kentan Gold Areas Ltd. have acquired interests and have opened up a series of promising auriferous pyritic impregnations of considerable extent. Organised prospecting on the concession of the Ukaranga Syndicate, which adjoins this area to the south, has also revealed the existence of both pyritic impregnations and of quartz reefs of promise.

The geology bears a very close resemblance to that of the Musoma Goldfield and a portion of the field is described by F. B. Wade in Short Paper No. 12 (*The Saragura and Associated Gold Occurrences of the Mwanza Area*), with two geological maps referring specially to the Saragura area. The Basement Complex is the important formation and consists of banded ironstones, acidic and sub-acidic tuffs, greenstones (epidiorite and amphibolite), granite, aplites, porphyries and dolerite. The acid dykes are of importance because it has been established at Saragura that the pyritic mineralisation is closely associated with certain of these intrusions. The gold-bearing portion of these mineralised zones is generally bounded on one side by the dyke contact.

Its limits in the other direction can only be determined by close sampling and assay, though close inspection of the auriferous ore usually reveals silicification and minute veinlets of quartz. This type of occurrence has so far in the field only been recognised in the banded ironstones, which usually form conspicuous ridges rising steeply from 500 to over 800 ft. above the surrounding country. This has favoured exploration by means of surface trenching, followed by adits, whereby the deposits have been traced to depths down to 300 ft. below the outcrop, proving an extensive strike of workable ore over good widths. Further exploration below this level is being carried out by diamond drilling. Should this work prove the extension in depth of the same types of mineralisation and similar values, a very large tonnage of payable ore will be assured and there should be no metallurgical difficulties regarding extraction.

The more basic members of the Basement Complex usually cover areas of lower relief and are, moreover, frequently

masked by superficial deposits of lateritic ironstone and soil which render discovery and opening up more difficult. Normal quartz reefs appear to favour these formations rather than the banded ironstones and examples of this type are found in the Rwamagasa region about 15 miles south of Saragura. These appear to be of the character of strong quartz lenses along important shear lines. Some promising values have been obtained, but development has not yet proceeded far. Portions of the Basement Complex of this area have not yet been fully explored.

Access to this region is by water from Mwanza to Smith Sound or Emin Pasha Gulf for the northern parts, or by the Kahama Motor Road for the more southern areas, connecting with the Mwanza-Tabora Railway at Isaka.

The Mkalama Goldfield (*Iramba-Sekenke region*)

This area lies some 90 miles north of the central railway and is served by the Manyoni branch line to Kinyangiri via Singida, which brings the Sekenke mine within 40 miles by motor road of rail-head.

The field lies on an east-west schist belt of the Upper Basement Complex intruded by granite and probably the most extensive individual schist zone in the country, for it is apparently continuous over a distance of about 150 miles, but it is masked in places by overlying alluvial and lake deposits. On the other hand it is well exposed across the fault-block plateau of Iramba. A detailed geological survey is now in progress, but sufficient is known to say that the formations correspond closely with those of the northern goldfields. Normal quartz reefs and pyritic impregnations occur, though only the former have yet proved workable.

The Sekenke mine, operated by the Tanganyika Central Gold Mining Co., Ltd., and the oldest and deepest mine in the Territory, is situated on the floor of the Wembere depression, a few miles west of the base of the Iramba plateau. It was worked in pre-war days and after a very chequered post-war career of misfortune, changing management and inefficient plant, has now reached a promising and interesting stage. The latest information indicates the continuance of good values at 70 ft. below the lowest, 400 ft. level. In 1934, 12,455 tons of ore were treated, giving 7,118 oz. of

bullion which contained 5,793½ oz. of fine gold, an average grade of 9·3 dwt. fine gold per ton, and the working costs were 43·60 shillings per ton. With the installation of a complete new plant capable of treating 3,000 tons per month, a considerable increase in production can soon be expected at a reduced cost per ton.

On the western scarp of the Iramba plateau, several small, but rich, reefs have been located and a small three-stamp battery has been installed to take the place of hand-dollying.

The old German mine at Kirondatal in the Central part of the plateau is owned by Commander L. Bicchieri, who has installed a five-stamp mill which commenced crushing in April 1934, and by the end of the year had treated 4,232 tons of ore from which 1,867 oz. of bullion containing 1,413 oz. of fine gold were recovered, an average of 6·5 dwt. of fine gold per ton.

The Lupa Goldfield

This field comprises an area of about 1,000 sq. miles and is situated in the south-west portion of the Territory, at 3,000 to 5,000 ft. above sea-level, about 250 to 280 miles south of the Central Railway at Tabora. A graded almost all-weather road of about 450 miles connects the field with the railway at Dodoma, which is 285 miles from the sea-port at Dar-es-Salaam. A new road is under construction from Itigi, which will increase the railage distance somewhat, but will reduce the road journey to about 280 miles and will have few grades of any consequence in contrast with the old road. A good system of roads recently constructed within the field itself has added much to the facilities for development in an area which was originally remote and roadless.

The Imperial Airways port at Mbeya, adjacent to the field, brings the area within six days of London and a day and a half from Johannesburg. The field started in 1922 with the discovery of alluvial gold and the figures given in the alluvial column of the production table (p. 46) represent almost entirely the yield from this region. The great increase in production from this source during the last three years, due to the high price of gold, is interesting in a field that had already been in existence for ten years. It was during

this later period, too, that most of the large nuggets were found—90 oz., 105 oz., 125 oz.—and a number ranging from 25 to over 50 oz.

Auriferous quartz reefs were found early in the history of the field, but distance from rail and absence of roads delayed development. With the improvement and extension of roads and the stimulus of the gold premium, much attention has been given to opening up the quartz occurrences. There are already about a dozen small mills on the field and larger-scale operations, which take longer to establish, are rapidly approaching the production stage. Prominent among these is the East African Goldfields Ltd., which has opened up three important reefs, the Luika, the Razorback and the Saza respectively. Shafts to over 200 ft. and diamond drilling to over 700 ft. on the Saza reefs show that the encouraging values and tonnage indicated by surface trenching and sampling can be expected in depth, averaging between 6 and 7 dwt. per ton. Other interests worthy of mention include the following:—East African Mining Areas, Tanganyika Diamond and Gold Development Ltd., Tanganyika Minerals Ltd., Lupa Exploration Syndicate Ltd., National Mining Corporation Ltd. The details of the geology are described in two bulletins of the Geological Survey, No. 3, *The Lupa Goldfield*, by D. R. Grantham, dealing with the western area, and No. 8, *The Eastern Lupa Goldfield*, by E. O. Teale, N. W. Eades and F. Oates with the eastern region.

Briefly, the field consists of an igneous complex characterised by a great variety of rock types, predominant among which, however, is a granitic gneiss, displaying a variable degree of contamination by older and relatively basic rocks. The quartz reefs are mostly localised in shear zones occurring in proximity to margins of young granite and its dioritic differentiates, intrusive into the granitic gneiss. Much still requires to be determined regarding the size, character and value of the ore shoots, but the recent valuable exploratory work by the East African Goldfields Ltd. in the Saza reef system is most informative and encouraging.

This occurrence consists of a strong system of closely-set quartz lenses arranged *en échelon* along a well-defined shear zone and the underground work above mentioned has confirmed the surmise of Grantham that these lenses would

recur in depth with no serious intervening gap. Further, the mineralisation shows no change, consisting dominantly of pyrites, a little galena and copper pyrites, the last-named usually in unimportant amounts. The gold values obtained also uphold the view that there is little or no secondary enrichment, the mineral association being of a primary character as suggested by the preliminary mineragraphic examination by Oates and also by the conclusion suggested by the physiographical considerations of general field work.

No serious metallurgical difficulties are expected in the treatment of the ore and some laboratory tests already made go to show that crushing to about 90 mesh, followed by amalgamation and cyanidation will yield an extraction of over 90 per cent. On the other hand, amalgamation alone, as often practised by small workers, can have but short life, for the depth of oxidised ore is very shallow, often within 50 to 60 ft. from the surface, below which the greater proportion of the gold may be so locked up in the pyrites and associated minerals that without the aid of cyanidation the extraction may be unprofitable. Though the treatment, as a rule, is simple, there are some occurrences which are highly cupriferous and these will call for special treatment. No other deleterious minerals have yet been noted.

A long dry season of five to six months and high evaporation combine to make water scarce in most parts of the field, during a portion of the year. A good supply exists in the Rukwa depression and this is made use of by the East African Goldfields by a lift of about 800 ft. and a pumping distance of several miles. Owing to its slightly alkaline character, it is not very satisfactory for steam purposes. Some excellent sites occur in different parts of the field for storage by means of dams, but the high evaporation losses need careful consideration and any large-scale engineering works of this character demand most careful survey and construction by experienced men. It may be possible to tap useful bore-hole supplies of moderate yield suitable for small-scale mining purposes and moderate-sized township or domestic requirements and this matter is being investigated by Government drilling.

Timber for fuel and mining purposes should be sufficient for immediate needs, but large-scale operators would do well to look ahead and make provision for the future.

The recent discovery of workable coal near Galulu Mission, within 25 miles of the western edge of the goldfield, offers the prospect of a valuable source of power.

In addition to the above-named goldfields, gold is known to be widely distributed in areas outside of these regions. Large areas of old rocks are still awaiting detailed geological examination and careful prospecting. This is now receiving extended attention by an increased staff of Government Geologists and Surveyors, and private enterprise has recently taken up large areas as special concessions for close examination. The immediate future, therefore, holds possibilities of considerable promise.

THE MINERAL RESOURCES OF JOHORE

A MEMORANDUM on the mineral resources of Johore, prepared by Mr. A. Bean, Acting Warden of Mines, was recently sent by the High Commissioner for the Malay States to the Colonial Office. As there is little published information available on this subject, the Secretary of State for the Colonies, at the suggestion of the Imperial Institute, kindly agreed to the publication in this BULLETIN of the particulars contained in Mr. Bean's memorandum; the introduction and statistics have been added by the Imperial Institute. The map illustrating this article is based on a large-scale map supplied by Mr. Bean, which has been deposited in the Colonial Office Library.

Johore, which is one of the Unfederated Malay States, lies at the southern extremity of the Malay Peninsula. It is bounded on the north by Pahang, on the north-west by Negri Sembilan and Malacca, on the west by the Straits of Malacca, on the south by the Strait north of Singapore and on the east by the China Sea. The ownership of all mineral lands is vested in His Highness the Sultan-in-Council, by whom leases to work minerals on State lands are granted.

The State of Johore comprises an area of approximately 7,400 square miles, or 4,736,000 acres, of which only 10,237 acres has been alienated for mining, viz. 9,335 acres for tin, 836 acres for iron, 63 acres for gold, 3 acres for china-clay. Approximately 50,000 acres has and is being reliably prospected, but little or nothing is known of the mineral resources of the remaining 4,675,000 acres.

Tin.—There are three areas (marked A, B and C on the map on p. 55) in which tin-ore is known and is being mined.

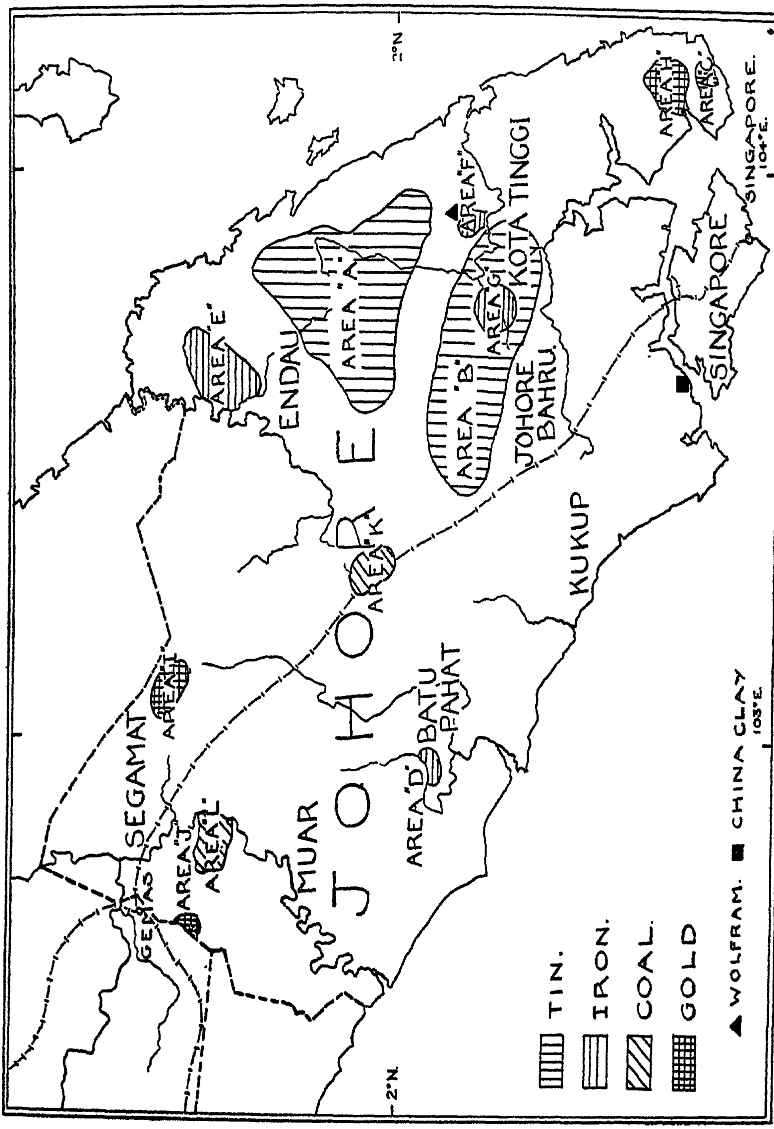

FIG. 1.—SKETCH-MAP OF JOHORE SHOWING DISTRIBUTION OF MINERAL DEPOSITS

In each of these areas the ore is found in alluvial deposits, the depths of which vary considerably. Tin-ore mining cannot be developed owing to the operation of the Tin Restriction Scheme, but prospecting is being fostered and encouraged with a view to locating the tin-ore reserves of the State.

In area A there are 68 small alluvial tin mines. Area B has 60 similar mines of various sizes and one tin-dredging company, while prospecting rights have been applied for over large areas in this district. In area C a fairly large gravel pump mine is operating in an alluvial deposit of tin-ore.

Iron.—At present, iron-ore is being mined in one area (D) situated in the Batu Pahat district and prospecting is being carried out in the three areas, E, F and G. For many years past iron-ore has been mined on a large scale in area D by a Japanese company. The life of the mine has not yet been definitely ascertained and it is proposed to carry out a development programme in the near future in order to estimate the reserves of iron-ore available.

One of the unworked iron-ore deposits in area E, situated in the district of Endau, bounded on the west by the Sungei Endau and Sungei Lenggor, is being thoroughly prospected by certain Japanese interests and 189 acres has been alienated for iron mining. A Japanese mining concern intend opening up a deposit in the north-west corner of this area on the bank of the Sungei Endau and there is every prospect of iron-ore mining being carried on in this locality on a large scale.

In area F a lease, covering 115 acres, for mining iron-ore has been granted in the vicinity of the village of Mawai in the district of Kota Tinggi and a Chinese company from Shanghai proposes to commence mining operations in the near future. Much prospecting has been done in this area, but no further payable iron-ore deposits have been located.

Prospecting for iron-ore is also being carried out by a Japanese mining company in area G, situated between Ulu Sungei Johore and Ulu Sungei Sedili Besar, but the grade of iron-ore so far located in this deposit is not very high.

Wolfram.—This mineral has been found near the village of Mawai in the district of Kota Tinggi (area F) and a Japanese company has applied for a lease over a portion of this area.

China-clay.—An area of 3 acres, situated at Pulai in the district of Johore Bahru in the south-west corner of Johore,

has been alienated for the mining of this mineral, but little or no work has been done on the area.

Gold.—This mineral has been found in alluvial deposits in areas H, I, and J.

In the Sungei Papan area, situated in the south-east corner of Johore in the district of Kota Tinggi, gold is being won from an area (H) of 63 acres under lease.

Prospecting rights have also been granted over 2,300 acres in this area. The results obtained to date from operations tend to show that the deposits are only of small dimensions, but can be worked on a small scale.

Prospecting in the Labis area in the northern portion of Johore in the district of Segamat (area I) has, so far, been disappointing and gold has not yet been found in payable quantities.

Rights to prospect have been granted over an area of 1,000 acres situated on the borders of Johore and Negri Sembilan near the village of Tangkak in the district of Muar (area J) and prospecting operations are being carried out. The gold is found in the alluvium in the valleys.

Coal.—Prospecting for this mineral has been carried on in two areas, Kluang and Kepong. Results obtained in Kluang (area K) proved disappointing and operations were stopped. The Kepong area (L), which comprises about 20,000 acres, is now being prospected and coal has been encountered in some of the pits and bores, but it is impossible to form any opinion as to the likelihood of finding a payable coalfield until more systematic drilling has been done.

It will be seen from the above details and from the accompanying map that the mineralised areas of Johore at present known are somewhat scattered and more work will be required before a definite statement can be made as to the potential mineral resources of this State.

Statistics available regarding the export of minerals from Johore during recent years are as follows :—

EXPORTS OF MINERALS FROM JOHORE

QUANTITY

	1930.	1931.	1932.	1933.	1934.
Tin-ore . tons	743	594	425	306	521
Iron-ore . ,,	729,251	488,877	485,067	408,644	578,180
China-clay ,,	410	396	186	30	143
Gold . oz.	—	—	20	72	76

NOTES

The Late Mr. Harold Brown.—It is with profound regret that we record the death on March 3, 1936, after an operation, of Mr. Harold Brown, O.B.E., Principal of the Plant and Animal Products Department of the Imperial Institute since its reorganisation in 1926.

Mr. Brown joined the scientific staff of the Institute nearly forty years ago. Throughout this long period he gave valuable service to the Institute in its work of developing the resources of the Empire and his wise counsels, wide knowledge and genial manner will be sadly missed, not only by his immediate associates at the Institute but by the many friends from overseas with whom he came in contact in the course of his work.

Mr. Brown started his scientific career as a Jacob Bell Scholar in the School of Pharmacy of the Pharmaceutical Society in 1894, and for a time carried out research work in their laboratories under the direction of Professor (now Sir) Wyndham Dunstan, F.R.S. When Prof. Dunstan became Director of the Scientific and Technical Department of the Imperial Institute, in 1896, Mr. Brown joined the staff as an Assistant Chemist and continued his research work, which was principally concerned with a study of the alkaloids of *Hyoscyamus muticus* and *Datura Stramonium*, the results of which will be found in the *Journal of the Chemical Society* for 1898-1901. Later, he devoted himself more particularly to the subject of rubber and became a well-known authority on the subject. In 1904, he visited the Sudan to investigate the rubber resources of the Bahr-el-Ghazal, and ten years later the first edition of his book on "Rubber: its Sources, Cultivation and Preparation" was published. He also played a leading part in the establishment of the rubber-testing laboratories of the Institute, which have since been taken over by the London Committee of the Rubber Research Schemes of Ceylon and Malaya.

Through the administrative positions which he held in later years Mr. Brown was enabled to exert a marked influence on the whole work of the Institute. This was recognised in 1930 when he was awarded the O.B.E.

The Exhibition Galleries.—During the past quarter, the Galleries have been repainted on a novel colour scheme. The two long Galleries have each been treated in three different shades, the central portion differing from the two wings in colour and yet identical in tone. The two shorter Galleries have been painted in yet other colours which, again, have harmonised in tone. By this means variety has been introduced

while harmony has been maintained. At the same time the arrangement of the Courts has been slightly changed. Hitherto the tendency has been to reserve the eastern, southern and western Galleries for the Dominions and India and the northern Gallery for the Colonies. In future the sequence will be strictly geographical. From India and Ceylon in the eastern Gallery (appropriately enough) will debouch the northern Gallery, which will lead via the Seychelles and Mauritius to East Africa, South Africa and West Africa, the Mediterranean Colonies and Palestine. The southern Gallery will lead, from India, via Malaya and Borneo, to Australia, Fiji and New Zealand, and thence via Samoa and the Falkland Islands to the West Indies and Newfoundland. And so to Canada, which comprises (again most appropriately) the western Gallery.

It would not be possible, in reasonable compass, to list all the new exhibits introduced into the various Courts during the past quarter. One innovation is, however, worthy of special mention. It is not enough merely to show specimens of economic products of the Empire in glass bottles or jars. Instead, it is better to group the exhibits so that each group tells its own particular story. How the cotton-seed of Uganda is divested of the linters which are used for stuffing material, blotting-paper, etc., and as the raw material for numerous cellulose industries ; and how the delinted seed is converted into oil, cake, husk and meal with all their residuary products. How the rabbit fur of New Zealand and the shellac of India combine to make the bowler hats of London city. How South African or Rhodesian or Canadian asbestos becomes insulating or building material, the lining for brakes, or fireproof suits for firemen. How many socks can be knitted from the wool off the back of a single sheep. How an Indian sheepskin is converted into a kid glove or an Indian kip into an army boot. These are all lessons in industrial technique which the general public (over half a million in 1935) is keen to learn ; and in each exhibit is implicit, rather than explicit, the element of Empire geography which it is the purpose of the Galleries to impart.

Colonial Visitors.—Officers on home leave from the Colonies have very kindly assisted us from time to time to bring the exhibits in our Galleries up to date. The following is a list of the officers who visited the Institute during the past quarter :

NOVEMBER

T. G. BENSON, M.A., Education Officer, Education Department, Kenya.
E. B. H. GOODALL, C.B.E., Senior Provincial Commissioner, Northern Rhodesia.
H. O. LINDSELL, Senior Resident Commissioner, Nigeria.
K. W. STEAD, C.B.E., Director of Customs, Excise and Trade, Palestine.
G. WALTON, Agricultural Officer, Northern Rhodesia.

DECEMBER

G. W. CHAPMAN, Assistant Conservator of Forests, Cyprus.
Sir G. J. LETHEM, K.C.M.G., Governor, Leeward Islands.
CH. G. PELAGHIAS, Department of Agriculture, Cyprus.
F. B. WILSON, Agricultural Officer, Department of Agriculture, Zanzibar.

JANUARY

J. R. AINSLIE, Chief Conservator of Forests, Nigeria.
D. HUGHES BAKER, Superintendent of Agriculture, Nigeria.
A. G. MACDONALD, Warden of Mines, Federated Malay States.
G. M. SALE, late Conservator of Forests, Mauritius, transferring to Palestine.
C. F. M. SWYNNERTON, Director, Tsetse Research, Tanganyika Territory.
E. S. WILLBOURN, Director of Geological Survey, Federated Malay States.

It is hoped that Dominion and Colonial visitors, or intending visitors to London, whose eye may be caught by this announcement, will come with or without notice to see our Galleries or to take an interest in the scientific and statistical work undertaken at the Institute.

The Empire Film Library, Cinema and Lectures.—As already mentioned in this BULLETIN (1935, **33**, 175), the Empire Film Library, which we inherited from the Empire Marketing Board, was opened at the Imperial Institute last June by H.R.H. the Duke of Gloucester. We hold it on trust from the United Kingdom Government for the free loan of the Empire films which it contains to schools and educational societies throughout the United Kingdom. We have added new films from time to time with the generous co-operation of the Dominion High Commissioners and Colonial Governments to replace worn-out or out-of-date films. By this means the Library has expanded and now comprises some 850 films descriptive of the life, scenery, or industries of the Empire. We undertake the distribution of General Post Office films also to schools and educational societies of the United Kingdom as an agency service rendered to the Postmaster-General. Last year our issues of Empire films totalled 17,000, and the audiences must have reached, on aggregate, the stupendous total of 3½ million persons. The Library is, of course, available also to provide films for display in four daily sessions in the Cinema Theatre of the Imperial Institute. Gifts of new Empire films, properly captioned or synchronised, are always welcome, to replace wastage and to maintain public interest in the Empire.

Once a week, or sometimes oftener, a lecture on some Empire subject is arranged to take place to the accompaniment of films and lantern slides in our Cinema Theatre. Our latest development in this field has been most interesting. Post-graduate students of the overseas Empire studying at the Institute of Education, have very kindly responded to our invitation to come and lecture, each on the country to which

he belongs. By this means a series of nine lectures has been arranged up to Easter and good audiences have been secured both from the schools and from the general public.

Annual Conference of the Textile Institute and Mather Lecture.—The following statement has been furnished by the Textile Institute.

"The Textile Institute, which has its Headquarters in Lancashire, will hold its annual conference this year in London, from June 3 to 6. Whilst not yet definitely decided, it is expected that some centrally-placed hotel will be chosen, at which the major portion of the members and visitors attending the event will stay, and at which the Conference sessions and banquet will be held. Four years ago, at Leamington Spa, the first Conference of a new series was held, characterised by being centred round one general subject, that subject forming part of the Institute's scheme of abstracting current textile literature and of the syllabus of the Institute's Examination in General Textile Technology.

"This policy, linking the two main functions of the Institute—Education and Publication—has since been pursued with increasing success. The fifth year, 1936, completes the first cycle of general subjects, and for the coming event the general subject is 'The production and properties of textile fibres.' London should prove a peculiarly appropriate centre for such a conference, for which an attractive series of papers has already been secured. It is hoped, moreover, to hold an Exhibition of Scientific and Technical Apparatus in conjunction with the event.

"Of recent years it has been the custom of the Textile Institute to arrange for the delivery of its 'Mather' Lecture at the Annual Conference. This plan is to be followed again on the above-described occasion.

"In recognition of his many years' service in connection with the investigation of and the encouragement of Empire fibre production the Mather lecturer for 1936 is to be Dr. Ernest Goulding, lately Vice-Principal, Plant and Animal Products Department, Imperial Institute, whose subject will be 'Textile Fibres of Vegetable Origin: Forty Years of Investigation at the Imperial Institute.' It is particularly gratifying to the Council of the Institute that Dr. Goulding has consented to deliver this important lecture."

The Imperial Institute offers its congratulations to Dr. Goulding on the honour thus bestowed on him.

Mr. H. N. Ridley.—The latest issue of *The Gardens' Bulletin, Straits Settlements* (Vol. IX, Part I, December 1935), is dedicated to Henry Nicholas Ridley, C.M.G., M.A., F.R.S., Director of Gardens, Straits Settlements, from 1888 to 1911,

on the occasion of his eightieth birthday. In the words of the Foreword to the *Bulletin,* "Mr. Ridley's work as a field botanist added more than that of any other single man to our knowledge of the Flora of the Malay Peninsula; his *Flora* is the foundation upon which all future work must rest; he actively pursued the experimental cultivation of agricultural plants at a time when agricultural interests in Malaya were at a low ebb; in particular, his persistent advocacy of the plantation of Para Rubber and his pioneer tapping experiments were largely responsible for the foundation of that industry upon which so large a share of the wealth of Malaya has rested; his reports on timbers, rattans and other forest products of the Peninsula were the first adequate works of their kind and embodied much original information; he added very considerably to the collection of cultivated plants, both Malayan and exotic, in the Botanic Gardens, Singapore."

Mr. Ridley's wide interests, not only in botany, but also in entomology, geology, and other branches of natural science, found expression in more than 500 books, papers and notes published during the period 1872-1935, a list of which is given in a Bibliography, compiled by M. R. Henderson and C. G. G. J. van Steenis, included in the *Bulletin.* The list of plants named in his honour include two genera (*Ridleyella* and *Ridleyinda*) and over 90 species of flowering plants and ferns.

The papers contributed to this special number of the *Gardens' Bulletin* include one by F. W. South, Chief Field Officer of the local Department of Agriculture, on "Mr. Ridley's Work for Tropical Agriculture"; another by B. J. Eaton, Director of the Rubber Research Institute of Malaya, on "Mr. Ridley and Rubber in Malaya"; whilst D. F. van Slooten, Acting Director of the Botanic Gardens, Buitenzorg, deals with "Mr. H. N. Ridley and the Flora of the Netherlands Indies." Other contributors, who in the main deal with problems in which Mr. Ridley was specially interested, include Professor E. M. Merrill, of Harvard; W. M. Docters van Leeuwen, of Leersum; C. A. Backer, of Heemstede; J. J. Smith, of Oegstgeest; Professor H. J. Lam, of Leiden; and members of the Staff of the Botanic Gardens, Singapore.

The Imperial Institute warmly associates itself with these world-wide tributes to Mr. Ridley's work. His contributions to the development of the economic resources of Malaya have naturally been of special interest and value to us. As far back as 1903 he rendered great assistance in the re-arrangement of the Malaya Court at the Institute, as recorded in the first issue of this BULLETIN (1903, **1**, 8), and we are pleased to say that he is still associated with the Institute as a member of the Technical Sub-Committee of the London Advisory Committee for Rubber Research.

Lemongrass Cultivation and Distillation.—The lemongrass oil of commerce is derived from two species of grass, viz. *Cymbopogon flexuosus*, the Malabar or Cochin lemongrass, which is found in the Tinnevelli district and in Travancore of Southern India, and *Cymbopogon citratus*, which occurs in most tropical countries, especially in Ceylon, Burma, Java, Mauritius and the Malay Peninsula.

Lemongrass flourishes under subtropical and tropical conditions, preferably at low altitudes, where the rainfall is fairly uniformly distributed throughout the year and the humidity of the atmosphere is high.

As regards soil conditions lemongrass is not very exacting, but makes more rapid growth on good well-drained soil, such as sandy loam. Lemongrass, however, is cultivated in Ceylon and in Madagascar on poor soils and under fairly dry conditions. In such cases, although it is stated that the oil is of a better quality, the yield is decidedly less; furthermore, it is not possible, owing to the slower growth, to cut the grass as frequently as that grown under better conditions.

Propagation of the plant is effected by division of the clumps. The portions separated, after shortening the leaves to about 3 in., are set out in rows about 3 ft. apart and at a distance of 1½ ft. in the rows. The spacing varies to some degree according to the nature of the soil, on rich soils the distance usually allowed being greater than on poor ones.

Prior to planting, the land should have been ploughed over and broken up to a fairly fine tilth. In some countries it is customary before planting to dig in a dressing of fertiliser or a leguminous crop. Planting should take place in the early spring or at the beginning of the rainy season, at a time when the soil is sufficiently moist not to require artificial watering.

During early growth the ground should be frequently hoed to check weeds and to conserve soil moisture. Besides having a retarding action on the growth of the plant, weeds introduced into the still with the cut lemongrass often result in an undesirable odour in the oil.

After the first year only slight cultivation is needed, since after it is well established lemongrass tends to retard weed growth.

Although lemongrass is not normally manured during growth, it has been advocated that a dressing of fertiliser, as soon as the plants have become well established in the field, is beneficial to the plant. An economical fertiliser is said to be one containing 4 per cent. nitrogen, 5 per cent. potash and 8 per cent. phosphoric acid, applied at the rate of 600 lb. per acre. This should be given as a side application and well worked in at the first cultivation.

The cutting of the grass may take place from four to nine

months after planting, depending on the climatic and soil conditions of the locality. The height of the grass when ready for gathering is about 2½ to 3 ft. The grass is cut by hand, using a sickle, about 9 in. above the ground-level. The number of cuttings varies from three to as many as seven gatherings per annum, according to the locality. The largest number of cuttings generally occurs in the second year of growth of the plant, when it is in full vigour. After this there is a falling-off in the rate of growth of the clumps and a decrease in the oil content of the leaves and after three or four years it is found necessary to replant the area.

The yield of fresh grass per cutting is approximately from 4 to 5 tons per acre. Allowing for an oil content of 0·2 per cent. in the green material this yield is equivalent to 16 to 20 lb. of oil per acre. The oil content is, however, often higher than this, sometimes reaching as much as 0·5 per cent.

Regarding the immediate treatment of the grass after cutting there appears to be some difference in opinion. Experiments in Malaya showed that by semi-drying the grass and hence saving labour in removing it to the still, there was no decrease in the quality or yield of the oil. It was, therefore, recommended that after cutting, the lemongrass should be spread out and allowed to dry for a few days, the loss in weight after 4 to 5 days being as much as 60 to 65 per cent. If the grass was piled, heating and fermentation ensued affecting both the yield and quality of the oil. On the other hand, experiments in the United States showed a considerable loss of oil on drying, although there was no effect on the citral content of the oil. It is usual in many of the countries where the grass is grown commercially to distil the fresh material as soon as possible after gathering.

The oil is recovered from the grass by the process of steam distillation. Up-to-date plant for this purpose consists essentially of three parts: (*a*) a boiler for raising steam; (*b*) a still in which the grass is packed; and (*c*) a condenser in which the mixed vapours of steam and oil are condensed. In view of the quantity of water required for the condenser the site of the still should be close to a regular water supply. The still, which should be made either of copper or iron (preferably enamel lined), is packed fairly full and steam passed in. The time taken for the distillation of one charge of grass should not be longer than four hours.

The mixture of condensed oil and steam is separated as far as possible in a separating funnel or other suitable apparatus. The oil should be stored in well-filled air tight containers in as cold a place as possible until ready for shipment. For transport the oil can be packed in tins or tin-lined iron drums without injury.

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Canada's Reindeer Herd.—Some years ago arrangements were made by the Canadian Government to bring a large herd of reindeers from Western Alaska with a view to establishing them in Canada's Far North as a source of supply of food and clothing for the natives. The venture involved a journey of some 1,600 miles round the north-west of Alaska, which occupied a little over five years. An interesting article by Miss G. C. McDonald describing the methods pursued in connection with the transfer of the animals has been published in the *Canadian Geographical Journal* for November, 1935. Further information, indicating the gratifying progress which has been made in the work of establishing the herd in the reserve of 6,600 sq. miles which has been set aside for it east of the delta of the Mackenzie River, is contained in a statement issued from the Office of the High Commissioner for Canada, from which the following particulars are taken.

The condition of the herd and the prospects for its future development are considered highly satisfactory. The first fawning at the Government Station took place early in the spring shortly after the animals had been delivered to representatives of the Department of the Interior, and as a result 811 fawns were added to the herd. The total at the station as shown by the August round-up was well over 3,000 animals. The movement of the animals to the winter range was begun

about the middle of September and it was expected to be completed early in November.

The delivery of the herd by the vendors took place in March, 1935 and the animals, after being inspected, marked, and counted, were turned over to the herders on the summer range, which extends along the Arctic coast east of the mouth of the Mackenzie River. Here the fawning took place and both the young and mature animals progressed rapidly on the splendid forage available on the reserve. With the approach of winter the reindeer were herded inland by easy stages to the present location on the winter range.

When the herd of 2,370 animals was delivered to the Government Station, the count showed that there were 1,498 females of all ages, 611 bulls, yearlings and male fawns and 261 steers. This showed a female percentage of over 63 per cent., which was considered highly satisfactory after the long drive from western Alaska. With the herd established on its new grazing range, Departmental officers in charge considered that for the better development of the herd the number of breeding males should be reduced. As a result the surplus animals now number about 580 steers of all ages. A certain number of the mature animals, that is those three years of age and over, will be slaughtered from time to time to meet immediate requirements in the North. In accordance with this policy a number were slaughtered in the autumn to provide meat and skins for the care of native children in the Anglican residential school at Shingle Point and the Roman Catholic residential school at Aklavik and for the native inmates of the two mission hospitals at the latter point.

In the opinion of officers of the Department of the Interior the range comprised within the reserve is the best along the whole northern rim of the Continent. Mosses and lichens cover the great expanse of the reserve and the northern part or summer range provides forage in abundance for the herd from June until September. The winter range, which extends southward along the easternmost branch of the Mackenzie River and borders the northern fringe of the timber-line is also well covered with the favoured plant food of the reindeer. Both ranges are well watered and comparatively free from predatory animals.

The work of training apprentices with the object of eventually establishing small herds among the natives has already begun and two youths, one an Eskimo and the other a white boy, have been engaged. These boys will serve under the six herders—three Lapps and three Eskimos—now on the staff of the station. The practice of training natives as herders and the distributing of numbers of reindeer to these apprentices as payment for their services has proved successful

in the development of the reindeer industry in Alaska; whether this system will be given a trial at the Canadian station is under consideration by the Minister of the Interior.

The Evidence for a Concealed Coalfield under the Thames Mouth.—Some interesting papers have appeared recently in *The Iron and Coal Trades Review* (1935, **131**, 386-388, 466-467, 516-519), in which Dr. H. Baker states that a new coalfield exists beneath S.E. Essex and the Thames estuary. He reached this conclusion during the investigation of the problem of the structure of the Kent Coalfield, which he was led to carry out because of the presence of overturned Carboniferous strata at Boulogne, and a similar inversion in the shaft of the Chislet Colliery in Kent. From the borings available the outcrop of the Carboniferous limestone has been proved beneath a cover of Mesozoic rocks everywhere round the field, except in the north where boring records are sparsest.

In 1914, a percussion boring was made for water at Sheerness and it was hoped to tap the Lower Greensand, but this formation is absent here, and at 1,297 ft. the base of the Gault was met. Further boring brought up chippings of shaly material. Down to a depth of 1,338 ft. the log describes the strata passed through as "sandstone changing to black rock and grey rock of a shale nature." This, Dr. Baker states, is not a description of the Lower Greensand, Sandgate Beds, but exactly tallies with the Coal Measures as present in the Chislet Colliery, 20 miles to the E.S.E. in Kent. The last 36 ft. of the bore was recorded at the site as "limestone," but the washed samples received by the Geological Survey were represented as "finely crushed dark-bluish shale or slate." The bore-log was appended "fine hard sandstone and grey shale to bottom of bore."

The Survey concluded that these particular chippings represented Silurian rocks, such as had been proved at Batsford, Ware, Cliffe, Bobbing, and Chilham, running in a N.W.-S.E. direction. For the same reason, apparently, the shaly rocks at Beltinge and Reculver (Kent) borings (years 1913 and 1914) were dismissed as Silurian. It is on the interpretation of this Sheerness boring that Dr. Baker bases an important part of his theory. He believes that the last measures passed through at Sheerness were Coal Measures below the Gault, then at the base Carboniferous Limestone, and that the boring was, in fact, put down on the edge of a new coalfield extending from Sheppey under the Thames.

The extension of this supposed field into Essex is inferred from a small number of borings which have indicated the general geological structure of the area, though no boring has reached the Palæozoic strata in the area where he believes coal will be found.

The structure at Chislet, where a limestone, believed to be of Carboniferous age, overlies Coal Measures, is interpreted, in the light of the Boulogne coalfield, as an overfold from the south, and to the north the Sheerness boring made to indicate a second fold replacing the Carboniferous strata in their correct order of deposition. Further evidence for the second overfold is taken as existing in the Beltinge (Herne Bay) and Reculver borings, hitherto classed as penetrating Silurian strata rather than Carboniferous. The Beltinge boring struck Palæozoics, immediately below the Gault, described as blue shale, 48 ft.; conglomerate, 11 ft.; blue shale, 746 ft. At Reculver the boring ends in "bind," 61 ft.

As is well known, the Lower Coal Measures of Kent are shales about 700 ft. thick in the middle of the basin, and thus if the lower rocks encountered in these bore-holes were Coal Measures, by analogy, they would be of the lower division.

Reviewing the position, there exists the Kent Coalfield, a N.W.-S.E. basin, pitching S E. and thinning out on approaching Chislet. Chislet Colliery is believed to lie on an E.W. overfold of the Carboniferous strata, which reaches the sea south of Ebbsfleet. North of this area, the Sheerness, Beltinge and Reculver borings are taken to be evidence for a second overfold, reinstating the normal Carboniferous succession, which rocks plunge to the north, where under the Thames, and perhaps extending into Essex, a second coalfield may be found. To prove this field Dr. Baker suggests borings should be made at Shoeburyness, Great Wakering and Foulness Island, where he considers the Coal Measures may be expected at a depth of 1,400 ft. directly below the Gault.

It appears that in Tilmanstone Colliery a marine band is present carrying many of the typical fossils of the Mansfield Marine Band of Yorkshire and Nottinghamshire which overlies the Barnsley Top Hard Seam. A boring at the shaft bottom passed through a 4 ft. 6 in. seam below this marine band, and assuming that the Yorkshire, Nottinghamshire and Kent coalfields were deposited in one basin, Dr. Baker makes the interesting suggestion that this may be the Barnsley seam.

India's Coal Reserves.—The nature and extent of India's coal reserves is a matter of considerable importance to that country's future industrial development, and hence a recent article on the subject by the Director of the Geological Survey of India is of considerable interest (*Rec. Geol. Surv. Ind.*, 1935, **69**, 336). After a careful study of practically all the coalfields, estimates have been made of the total quantities of coking and non-coking coals still available in India and the period which these supplies are likely to last. The reserves may be summarised as follows:

RESERVES OF GOOD QUALITY COKING AND NON-COKING COAL IN INDIA AT END OF 1932

(millions of tons)

Coalfields.	Coking coal.	Non-coking coal.	Total.
Giridih . . .	38	—	38
Raniganj . . .	241	1,560	1,801
Jharia . . .	900	350	1,250
Bokaro . . .	515	7	522
	1,694	1,917	3,611

Other fields, including Karanpura and Talcher-Korba = 910

Total reserves coking or non-coking coal = 4,521

In previous discussions on the length of time which stated totals of coal would last, it has been assumed that the progressive annual increase in the consumption of coal in India would be 5 per cent. In practice, however, these anticipations have not been realised, owing partly to this estimate having been over liberal even for normal circumstances and partly due to abnormal economic conditions. In 1918 the total Indian output was approximately 20 million tons, so that on the basis of a 5 per cent. annual increase the output in 1933 would have been of the order of 40 million tons, whereas it was actually 19,789,163 tons.

The effects of the world depression are shown by the decreased production during the last three years, as shown by the following figures, and it is difficult to make any prediction concerning the growth of the industry.

OUTPUT OF COAL

	Tons.
1929	22,418,732
1930	23,802,942
1931	21,796,435
1932	20,153,384
1933	19,789,163

The total reserves of good quality coal (4,500 million tons) would, on an annual consumption of $22\frac{1}{2}$ million tons, last for 200 years if 100 per cent. extraction was secured. Unless something effective is done to cause an alteration in the system of working coal in India, it would appear from the data available that not more than 50 per cent. will be brought to the surface. On this assumption the Director believes that, without allowing for growth in the coal industry of India, the reserves of good quality coal will be exhausted in 100 years. Should the price of first-class coal rise, then the use of second-class coal will be resorted to, when the supplies will, of course, last a proportionately longer time.

This short life is made further disturbing when the iron-ore resources, of which those of Bihar and Orissa alone are

estimated as of the order of 3,000 million tons, are considered. To smelt all this by present-day methods a high quality metallurgical coke is necessary in the proportion, roughly, in the terms of raw coal, of one ton of coal to one ton of iron-ore smelted. But out of the 4,500 million tons of good quality coal available no more than 1,700 million tons are coking coal of superior quality.

	1931		1932	
	(a) Total production of coking coal.	(b) Consumed in coke making.	(a) Total production of coking coal.	(b) Consumed in coke making.
Giridih . .	713,133	33,209	583,243	32,724
Raniganj .	1,960,000	12,456	1,925,000	12,878
Jharia . .	8,292,000	1,687,681	7,269,000	1,585,733
Bokaro . .	1,656,597	21,123	1,348,973	4,637
	12,621,730	1,754,469	11,126,216	1,635,972

From these figures it can be seen that of the total amount of coal won in India in 1931 and 1932 suitable for the manufacture of metallurgical coke, only 13·9 and 14·7 per cent. respectively were used for the manufacture of hard coke. Of the coal used for coking in 1931 and 1932, 96·2 and 96·8 per cent. respectively were derived from Jharia, showing the overwhelming extent to which the manufacturers of such coke rely upon that coalfield. This may be taken as an index of the superiority of the Jharia coal over the other coals for this purpose, except those of the small Giridih field. The Raniganj coal has, in the main, to be mixed with Jharia coal, and the Bokaro coal is higher in ash content. The tables also illustrate the fact that on the basis of a 50 per cent. loss in mining nearly 25 million tons in 1931 and 22 million tons in 1932 of good coking coal were consumed, immobilised, or wasted underground, and at this rate the Jharia coking coals may be exhausted in 33 years unless mining practice is improved.

There are also some very good coking coals of low ash content of Tertiary age in Assam, especially in the Mokum field, but the high sulphur content makes it doubtful if such coal would make a usable metallurgical coke. Research on the froth flotation of Indian coals has shown this sulphur to be evenly distributed throughout the coal, and it has been inferred that it cannot be removed by any physical process at present known.

By sand-stowing, which allows a greater fraction of coal to be won by lessening the amount to be left for roof support, the extraction could be improved from 50 to 80 per cent. and the life of the field would then be 80 years.

It is shown that the total available supplies of good coking coal appear to be inadequate for the supplies of iron-ore, and accordingly means should be taken to conserve them.

The Brown Coal Deposits at Yallourn, Victoria, Australia.—Some years ago it was decided to utilise the extensive brown coal deposits at Yallourn on the Latrobe River, east of Melbourne, Victoria, and the *Sixteenth Annual Report of the State Electricity Commission of Victoria* gives an interesting account of the present-day development of the deposit.

In the area, which includes Yallourn, it is estimated there are 6,000 million tons of brown coal available, which amount, if extracted at the rate of 10,000 tons a day, would last approximately 1,600 years. The opening up of this deposit of brown coal was begun in June 1922, and borings proved thicknesses from 137 ft. to 206 ft. and averaging 163 ft. The overburden is 30 ft. thick and is easily removed by bucket-dredges. Coal-winning operations were in the initial stages in June 1924, and in the first year 442,560 tons were obtained. Since then the output has steadily increased to the present figure of nearly 2 million tons annually.

The following is the average composition of the deposit:

	Per cent.
Moisture	64·0
Volatile hydrocarbons	19·4
Fixed carbon	15·9
Ash	0·7
	100·0

The coal is won by machinery from two levels and the output from each dredge, one at each level, is 4,000 tons per 8-hour shift. This quantity supplies a large power station (125,000 kw.) and a briquetting factory in about equal proportions. The electric power is transmitted to Melbourne, about 100 miles distant, and the briquetting plant produces about 1,200 tons of briquettes from 4,000 to 5,000 tons of brown coal a day. The process of briquetting consists of crushing, screening, drying, cooling and pressing the coal. It commences with 65 per cent. moisture and finishes with 14 to 15 per cent. No binding material is necessary.

The composition of the briquettes is:

	Per cent.
Moisture	14·00
Volatiles	42·40
Fixed carbon	41·75
Ash	1·85
	100·00

On December 1, 1934, the whole workings were flooded by the Latrobe River, and it was not till June 1935 that the area was completely dewatered.

At present investigations are being carried out on the hydrogenation of Victoria brown coals.

The Italian Coalfields.—The coalfields of Italy are being extensively developed in an endeavour to meet the national demand for fuel, in part at least. This is the second occasion on which Italy has attempted to exploit her two principal fields, one on the island of Sardinia, and the other at Arsa in the province of Istria, south-east of Trieste.

The coal deposits of Sardinia (*Iron Coal Tr. Rev.*, 1935, **131,** 639) contain three types of coal, a so-called anthracite, a Tertiary coal and a semi-lignite, the fields being in Ogliastra in the east of the island and Iglesiente in the south-west. The former yields principally anthracite.

In Ogliastra there are three local coalfields, the Seui, Seulo, and Perdasdefogu. The first was discovered in 1830 and has been extensively surveyed. It contains seams up to 13 ft. thick under a cover not exceeding 330 ft. at the deepest points and capable of yielding 2 million tons of coal per annum. Coal has been worked here for the last 25 years to supply a neighbouring zinc-smelting plant.

The Barbagio di Seulo area is mainly anthracitic and is particularly suited for lime roasting, low-quality gas generation, and steam raising.

The Perdasdefogu field lies on a plateau about 2,000 ft. above sea-level in the south-east of Sardinia, and the anthracite was worked during the Great War on a comparatively large scale. The chief colliery is that of Muraghe San Pietro, which works 13 seams up to 39 in. thick, and the entire area is surrounded by iron-ore deposits which are being worked at four mines.

Around Gonnesa or Bacu Abis in the south-west of the island lies the Iglesiente coalfield, which has an area of about 25 sq. ml., several seams with a total thickness of 10 ft., and an estimated reserve of 50 million tons. Mining began here in 1877, when coal was obtained from open cuts and attempts were made to drive underground workings. The War period production reached 52,987 tons in 1918, but the trade declined, and in 1927 the old company closed down, being replaced by a second concern under which the equipment of the pits was modernised. Output was extended till financial troubles virtually ended the work, and from 1932 onwards only maintenance staffs were employed to preserve the machinery and plant. The very small tonnage now being raised from the Bacu Abis pits is utilised at a stand-by electricity generating station near Cagliari, where the furnaces burn the coal, untreated, merely requiring a large volume of secondary air to maintain combustion. The coal of this area contains a high percentage of sulphur (9 per cent.), which decidedly limits its industrial application.

The coal from the Arsa field near Trieste, where the mines

are worked by a State concern, also suffers from a high sulphur content (7 to 8 per cent.), although it is claimed that the sulphur is present in organic form and does not cause any special difficulties. This, however, has not been confirmed when the coal has been used as bunkers, in which connection boiler damage has resulted. The output in 1931 from this field was 155,000 tons shipped as bunkers and in 1933, 148,000 tons. The price of this coal has hitherto not enabled it seriously to compete with imported fuels of better grade.

The output of coal in Italy in the years 1932-3-4 was as follows (see *Statistical Summary, Imperial Institute*, 1935) :

Type of Coal.	1932. *tons.*	1933. *tons.*	1934. *tons.*
Anthracite . . .	47,004	66,644	83,212
Bituminous . . .	204,390	262,439	284,481
Brown . . .	370,107	376,712	402,162

These figures, when compared with the imports of coal, show how inadequately the Italian sources meet the present demand.

The following are Italy's coal imports :

Type of Coal.	1932. *tons.*	1933. *tons.*	1934. *tons.*
Anthracite . . .	895,718	949,271	1,105,633
Bituminous . . .	6,737,363	7,444,295	10,230,047
Brown . . .	45,862	46,464	47,353

The United States producers are now supplying to Italy quantities of " Pocohontas " coal, which they claim to be equal to Cardiff prime steam coals. The c.i.f. prices at the present prevailing rates permit this competition.

The whole of the Italian imports are under the control of a State department.

Low Temperature Carbonisation of South African Torbanite.—The torbanite deposits of the Ermelo district, Transvaal, have during the last four years been explored by the South African Torbanite Co., assisted by the British Burmah Petroleum Co., who have put down some 80 bore-holes to prove the deposits. According to a recent report (*Financial Times*, December 31, 1935, p. 4) sufficient torbanite has been found to last for 20 years, at the present rate of working, and in addition, the company has rights over a further 200 sq. miles of territory.

The business of the company is carried on at Ermelo, where mining and treatment of the torbanite is undertaken, at Boksburg, where the refinery has been established, and at Durban, where storage tanks have been erected to receive imported crude oil for the plant at Boksburg.

At Ermelo the deposits are worked in open cuts and the

torbanite is treated in two Salermo retorts each of 75 tons per day capacity. These retorts consist of a series of semi-cylindrical troughs bolted together in side-by-side fashion and each carrying along its axis a steel shaft fitted with paddles. Rotation of these shafts causes the paddles to sweep the material placed in any particular trough into the next, until eventually it passes through the whole series. The troughs are heated to a temperature of about 450°C., either by gas or oil, and above them are erected floors for drying the torbanite before it is fed into the carbonising system (*Industr. Chem.*, 1935, **11**, 495-499).

The gases and oil-vapours produced are removed at several special points in the retorts, determined by experiment. This obviates the danger of "cracking" the products of the carbonisation and, by reducing the velocity of the gases to under 2 ft. per second, greatly minimises the formation of dust.

The average yield from one ton of good quality torbanite is:

Dry oil (sp. gr. 0·875) . .	57·7 gals.
Liquor	12·9 gals.
Gas	2,230 cu. ft.
Residue	12·9 cwts.

The oil contains 0·5 per cent. of phenol and the gas yields 2·5 gals. of light spirit (aviation) on scrubbing.

One ton of poor quality torbanite yields:

Dry oil (sp. gr. 0·936) . .	26·7 gals.
Liquor	18·3 gals.
Gas	1,815 cu. ft.
Residue	14·9 cwts.

The oil contains 2 per cent. of phenol and the gas yields 3 gals. of light spirit (aviation). The spirit produced from the torbanite has been tested in England and America and found to be of high quality.

At Boksburg, the refinery treats both the raw products of the Ermelo plant and imported crude oil. There is storage available for 3,000 tons of crude oil, 2,000 tons of petrol and 1,000 tons of liquid residues. Actual production of petrol from the South African torbanite would have taken place in the latter part of 1935, but for a small fire at the refinery.

Two tanks capable of holding 4,500 tons each have been erected at Durban and the first cargo of crude oil arrived in August 1935. The petrol is to be marketed by the South African Motor Traders' Association and the Petrol Retailers' Association, under the title "Satmar Petrol," at a price 2*d.* per gal. below that prevailing for other brands.

Alberta Petroleum and Natural Gas Developments.—In Canada the production of petroleum, which occurs chiefly in Alberta, has shown a steady increase in recent years, due to the development of a new field in the foothills of the Rocky Mountains. The history and exploitation of these Alberta fields has been described recently by W. Calder and R. M. S. Owen (*J. Inst. Petr. Tech.*, 1935, **21**, 753-773), from whose paper the following details were obtained.

The existence of gas in this area was known for many years, but the first attempts to exploit it were made in the Medicine Hat district after 1883, and in 1905 gas was tapped at two horizons, one at 600-700 ft. and the other at 1,000-1,100 ft. After a time surface water penetrated the gas horizon, due to faulty drilling of the shallow wells, and the flow declined. Even the deeper drillings in recent years have evinced this trouble. Government engineers, however, proved the trouble to be due to corroded well casings rather than to an upward encroachment of water into the gas sands, and, after being relined and cemented, the wells again produced without interruption. On the basis of this experience three additional wells were drilled and yielded 2·9 to 3·7 million cu. ft. of gas per day with an initial pressure of 500 lb. per sq. in. There are now 26 wells producing gas for the street lighting system from the lower horizon in the town area, with an average pressure of 369 lb. per sq. in. and an average open flow of 1½ million cu. ft. per day.

The success of the Medicine Hat venture stimulated prospecting in other areas, and in 1908, at Bow Island, 40 miles west of that town, sufficient gas was obtained to justify the construction of a 16 in. main to Calgary (168 miles). By 1922 this second field had passed its peak and was declining, when the Foremost structure was discovered further south and relieved the heavy withdrawal from the Bow Island field.

Immediately the surplus gas from the Turner Valley petroleum field became available, a thorough overhaul of the Bow Island field was made, many old wells being plugged, and in 1930 the area was repressured. A total of 7,259 million cu. ft. has been forced into the depleted sands and the area pressure increased from 246 to 478 lb. per sq. in.

In mid-northern Alberta natural gas is known to exist at several points, but the Viking district is the only one being drawn on, gas being sent by a 77-mile pipe-line to Edmonton and intervening towns. Other known and partly developed gas areas include Redcliff, Cypress Hills, Brooks, Wetaskiwin, Fabyan, Wainwright, and Ribstone.

Only three petroleum-producing fields have yet been developed in Alberta; i.e. Turner Valley, Red Coulee and Wainwright. The Turner Valley field was discovered in 1913

when a light crude oil of 0·770 sp. gr. was discharged from a well bored to about 2,400 ft. The Great War checked the work, which was not resumed until 1924, when the Royalite Well No. 4 struck wet gas under high pressure, which caught fire. The conflagration was eventually extinguished, and a daily flow of 21½ million cu. ft. of gas, which yielded 500-600 barrels of naphtha, was obtained. This well, which may be classed as one of the world's big producers, continued till 1929, and there are now 90 producing wells located over an area approximately 1 mile wide by 12 miles long.

The Turner Valley structure is a narrow overthrust fold running N.N.W.-S.S.E. with steeply dipping flanks. In the shallow wells the limestone formation which carries the oil was encountered at 3,450 ft., and in those located away from the coast greater depths had to be drilled. Water trouble has been confined to the upper strata and has been easily cemented off.

Wet gas is obtained from the wells, and after scrubbing to remove the naphtha, 30-40 million cu. ft. in mild weather, and 50-70 million cu. ft. daily over the remainder of the year, are sold, the excess gas being destroyed. The crude oil, which is of high grade and ranges in gravity from 35° to 50° Bé., and which is encountered at 2,500 to 4,500 ft., has aroused little interest, possibly because it occurs in compact sandstones which do not readily permit an immediate free flow of oil.

In the Red Coulee area only five wells are producing, and in 1934 yielded over 200,000 barrels. Other wells sunk encountered good inflows of oil at the rate of 50-70 barrels per day, but they were abandoned after being drilled into bottom water at some depth below the oil horizon.

At Wainwright, although there is production from 11 wells distributed over a large area, operations have been erratic and the output small ; at no well has the daily flow exceeded 35 barrels. Despite this, there are good indications that the productive life of the wells will be of long duration, two having been in production for six years, and that if sufficient wells are drilled, at least six to each quarter section (160 acres), the returns, even at the low rate of 20 barrels per day, should prove remunerative.

At Pekisko, approximately 10 miles south of Turner Valley, a well drilled near the Prince of Wales' Ranch encountered a promising horizon at depth, the crude oil rising nearly to the surface. The actual production rate is unknown, as no continued test has been made. A similar discovery has been made at Bragg Creek, north-west of the Valley.

To the north, at Athabaska Landing, a flow of heavy crude oil (12·1° Bé.) has been met recently at a depth of 1,650 ft. issuing from a sand 50 ft. in thickness. Gas in quantity did

not appear, and it is therefore improbable that any sensational daily outputs will be obtained from wells put down in this area. The prospects for small persistent wells, producing over many years, are encouraging, however, should the sand be continuous over a large area.

As an index of the progressive increase in crude oil production in Alberta, the following table gives the annual production in barrels of 35 Imperial gallons each.

1925	2,926	1930	119,805
1926	8,590	1931	109,506
1927	41,863	1932	63,506
1928	78,908	1933	60,155
1929	90,411	1934	55,174

The decline in the production since 1931 has been attributed to work being concentrated on drilling wells for wet gas production, a statement which is apparently supported by the increased output of naphtha alone, which rose from 854,116 barrels in 1932 to 952,885 barrels in 1933, and to 1,210,766 barrels in 1934.

The foothills extend for a distance of over 250 miles in Alberta, and all along this length favourable geological conditions, and in many places active oil-seepages, have been located. It is, therefore, likely that other oil-producing areas similar to the Turner Valley may be developed in the future.

Petroleum Developments in the Bahrein Islands.—In 1930 the Standard Oil Co. of California acquired a concession covering the oil rights of the Bahrein Islands, and its subsidiary company, the Bahrein Petroleum Co., was floated in Canada to develop the oilfield.

The Bahrein Islands, seven in number, lie some 20 miles off the south-western coast of the Persian Gulf. Bahrein Island, the largest, 32 miles by 9½ miles, with two much smaller islands, Sitra and Muharraq, form the chief members of the group. All are desert islands of low elevation, the highest point on Bahrein being 443 ft. above sea-level. Approximately one-third of the total population of 120,000 live in the city of Manama at the northern end of Bahrein.

Structurally, Bahrein Island is an elongated dome of Eocene age, puckered by minor folding, and the limestones, sands, and marls of which it is comprised are covered at the flanks by recent sands and gravels. The dome rises into a hill known as Jebel Dukhan (Hill of Smoke).

The first well, Jebel Dukhan No. 1, located at the south-eastern base of the small group of peaks forming the Jebel Dukhan, was started in October 1931 and completed in June 1932 as a flowing well yielding 800-1,400 barrels of oil per day

from a depth of 2,008 ft. A second well, 2 miles north of No. 1, yielded 1,550 barrels daily at the same depth. Despite trouble from water, which was cased off, a third well, which had been sunk down the flank of the hill in a north-easterly direction from No. 2, produced 700-800 barrels daily.

Since these drillings were completed the island has been blocked out from a N.-S. base line in order to give equal drainage area to each well. Each block contains 20 sections, and each section is allotted 81 well locations. There are now 16 wells producing oil, and further drilling is being carried out with two rigs.

Oil is stored in three tanks having a total capacity of 250,000 barrels, and is delivered to tankers in the Sitra Island anchorage by a pipe-line capable of conveying 5,700 gals. per hour.

On Bahrein Island a refinery is being built which the company hope to have completed in six months, a record for the construction of such a plant on what is almost a barren island. This refinery will have facilities for dealing with 10,000 barrels a day, and 18 floating roof tanks, each of 55,000 barrels capacity, will store the product. It is possible that another short submarine pipe-line will have to be laid to handle the refined oils.

The Metal Industries of Italy.—An interesting account of the Italian metal industries has recently been given by C. W. Wright, the American Vice-Consul at Rome, in *Special Supplement No.* 1, 1935, to *Mineral Trade Notes*, published by the United States Bureau of Mines.

According to this work Italy is dependent to a large extent on foreign supplies of the principal non-ferrous metals, with the exceptions of aluminium and zinc. In 1934 imports accounted for 11 per cent. of the Italian domestic consumption of lead, 38 per cent. of the antimony, and virtually all the copper, tin, and nickel. Zinc-ore resources should suffice for national needs for many years to come, although small amounts of metallic zinc were imported in 1934. Additional smelting works now under construction, however, are expected to make Italy completely self-sufficient with regard to this commodity. A large exportable surplus of aluminium has been created, and domestic resources of bauxite are deemed large enough to maintain production on an expanding scale for some considerable time. Leucite, although not an economic source of aluminium at the present time, is regarded as forming a large potential reserve of the metal. Most other metals have to be obtained from abroad on account of the inadequacy of domestic deposits.

The Extraction of Alumina from Clay.—The production and consumption of light metals, particularly aluminium, has increased to a remarkable extent within the last few years. While the domestic and general industrial uses of aluminium have been extended, the complete dependence of the rapidly developing aircraft industry upon an adequate supply of aluminium is of great significance. For this purpose there is no cheap or efficient substitute for aluminium. Countries such as Germany, Russia, Italy, and Japan, which are striving for economic self-sufficiency, have been concerned with their resources of aluminium ores and have been investigating the possibility of obtaining aluminium from materials other than bauxite, from which it is at present extracted. In other countries in which this problem has been studied, such as Norway, a plentiful supply of cheap electric power, but no bauxite, is available, whereas in the United States the bauxite, when it occurs, is often remote from the sources of power.

Silicates containing alumina as a major constituent occur widely distributed in nature, and a number of them, including kaolin, leucite, labradorite, nephelite, and various shales and clays, have been suggested as possible sources of alumina. The Bayer process, which is mainly employed in the treatment of bauxite, requires an aluminous material, low in silica, but a fair amount of iron and titanium is permissible. Bauxite is the only material occurring in any quantity which will fulfil these conditions. Other processes such as the Hall furnace process or those involving acid extraction can treat material containing a large amount of silica, although in the acid processes the amount of iron contained in the raw material should be small, as the main difficulty encountered is the separation of iron in the solution from aluminium. Accordingly silicates which contain little iron are essential for the success of the latter processes. A good quality kaolin would be satisfactory.

Of recent years the acid extraction processes have been very fully studied, and numerous applications for patents, referring to pre-treatment of the silicates, type of acid used, conditions of extraction and methods of purifying the solutions obtained, have been made ("Aluminium and its Production," J. D. Edwards, F. C. Frary, and Z. Jeffries, 1930). Clays vary in composition and properties and respond differently to pre-treatment, and hence in various cases it is recommended that the clay should be ignited in air or in a vacuum at a given temperature before extraction. The acids used include sulphuric, hydrochloric, nitric, sulphurous, and hydrofluoric, and in some cases the extraction is carried out at high temperatures and pressures. Similar processes have been suggested which involve sintering clay with acid or normal sulphates of sodium or ammonium and leaching out the sulphates

formed, also heating with acid ammonium fluoride, whereby silicon fluoride is volatilized and aluminium fluoride extracted from the residue.

These acid processes could not be commercially developed until the recent introduction of plant constructed of corrosion-resistant nickel-chromium steel, as all the usual constructional materials were seriously attacked by the acids used, especially in high-pressure extractions. The success of these processes will depend upon a cheap supply of the extracting acid, and the particular acid employed will be mainly governed by the locality in which the works are situated. In Norway, where cheap nitric acid made by the atmospheric nitrogen-fixation process is available, the effect of this solvent has been most studied. Similarly in the United States, where sulphuric acid can be cheaply produced and power supplies are available in the vicinity of deposits of good quality clay, the sulphuric acid extraction process has been considered ("Acid Processes for the Extraction of Alumina," *Bull.* 267, *U.S. Bur. Min.*, 1927).

Alumina suitable for the electrolytic production of aluminium should not contain more than 0·05 per cent. of ferric oxide. The purification of the acid solutions and the preparation of pure alumina or aluminium salts from them is thus an important part of the process. The main separation methods suggested depend on crystallisation of aluminium salts or double salts and ignition to alumina, or fractional hydrolysis by careful adjustment of the acidity of the solution. Iron and titanium hydroxides are precipitated first and filtered off, and alumina is obtained by ignition of the aluminium hydroxide finally precipitated.

Other means of separation have also been suggested, such as the prior precipitation of iron as Prussian blue, and the chlorine treatment process, in which iron is vaporized as chloride by passing chlorine over heated impure alumina mixed with coke. The separation method recommended by the United States Bureau of Mines employs fractional crystallisation of the sulphates, iron remaining in the mother liquor, and ignition of aluminium sulphate to oxide. The cost of this process of sulphuric acid treatment has been worked out and it is estimated that alumina can be produced as cheaply as in the Bayer bauxite process. There have, however, been no commercial developments, probably owing to general industrial conditions.

While the majority of recent patents dealing with the extraction of alumina from silicates have had some connection with the acid extraction process, a few of them deal with dry methods of extraction, for example, the electric furnace modifications of the older Hall method. All the processes

mentioned above have not been tested on clays ; in some cases other silicates are intended to be treated, but clay can probably be substituted with but slight alterations.

The possibility of producing aluminium from silicates has been studied in Germany for some time, and under the present regime research has been accelerated and small-scale experiments have been carried out which would enable a large-scale plant to be erected and worked if occasion arose. Practically all the bauxite consumed in the German aluminium industry is imported from France, Hungary, and Yugoslavia. The bauxite deposits in the Vogelsberg district, which were worked during the Great War, are being utilized again, but the production is small and is unlikely to increase. At the present price of bauxite imported into Germany the clay processes cannot be economically operated, but if supplies were materially reduced or the price increased, they would be in a position to start production.

The I.G. Farbenindustrie has an experimental plant at Bitterfeld equipped to produce aluminium from clay, using hydrochloric acid as a solvent. The solution obtained is saturated with hydrochloric acid gas, aluminium chloride free from iron is precipitated and ignited to yield alumina. The Vereinigte Aluminiumwerke has developed an electrothermal process and has purchased clay deposits at Bautzen which are stated to ensure its raw material supplies for 100 years in case bauxite shipments fail. A modification of the nitric acid extraction process, which has been tried in Norway for the treatment of labradorite, has been worked out by Max Buchner and F. Gewecke. The extraction is carried out at high temperature and pressure in apparatus of chromium-nickel steel (*Min. Tr. Notes*, U.S., 1935, **1**, No. 5, 4).

In 1933 it was announced that Rontgen at the Technische Hochschule at Aachen had developed a process for fusing aluminium silicates in an electric furnace with a reducing agent to produce crude aluminium alloyed with iron and silicon. This material is added to a molten bath of iron sulphide to produce aluminium sulphide and ferro-silicon. The aluminium sulphide is then used instead of alumina in electrolysis, a rock salt bath being employed instead of cryolite (*Miner. Ind.*, 1933, **42**, 20).

Japan has no bauxite deposits, but efforts to establish an aluminium industry, using silicate as raw material, have been made since 1915, when the Nippon Aluminium Co. began producing aluminium from silicate, but as the metal produced could not be obtained purer than 94 per cent., the process was abandoned. The Nippon-Manchukuo Aluminium Co. are now erecting a plant for the treatment of Manchurian clay, using the Suzuki process. The capacity of this plant will at

first be 5,000 tons, and part of the process was expected to be operating by the end of 1934. The aluminium works which are being constructed by the South Manchuria Railway Co. will employ the same process and raw materials.

Suzuki's process is a development of Hall's dry process. The raw material is crushed and heated in an electric furnace with coke to reduce the ferric oxide and silica, which form a lower layer of ferro-silicon. The upper layer of alumina is removed, crushed, replaced in the electric furnace, and heated to 500-600°, while a calculated amount of chlorine is passed through to convert the iron and silicon residue into chlorides, which volatilize. The electrolysis of alumina is then carried out with cryolite as usual. The process will be valuable in Manchuria, where it is estimated there are 1,500,000 tons of shale containing 50 per cent. of alumina (*Miner. Ind.*, 1934, **43**, 25).

There has been a rapid increase in the production of aluminium in the Soviet Republic in the last few years, and the extraction of the metal from domestic bauxite has developed to such an extent that it is claimed that the country is no longer dependent on foreign supplies. It has, however, been thought necessary to study the possibility of utilising other sources of aluminium, and a small-scale plant for the treatment of nephelite concentrates has been perfected, using a soda-lime fusion process. A mass production works is now under construction at Kandalaksha (Murmansk). The first section will have an output capacity of 40,000 tons of aluminium, the nephelite treated being a by-product in the working of apatite (*Light Metals Res.*, 1935, **4**, No. 11, 184).

The possibility of utilising Italian leucite as a source of alumina and potash has been realised, and a plant producing 4,000 to 5,000 metric tons of aluminium per year started operations near Civitavecchia in 1931, using the Blanc nitric acid extraction process. Heavy import duties were imposed by the Italian Government on manufactured salts, potash, and alumina, doubtless with a view to assisting this industry. According to the United States Bureau of Mines, this plant suspended operations in 1933 owing to difficulties encountered, and experiments to improve the process are now being made ("Metals of Italy," *Spec. Suppl. No.* 1, 1935, *Min. Tr. Notes, U.S.*).

An important problem affecting the working of acid-extraction processes is the disposal of the large quantities of highly siliceous insoluble residue obtained. The great bulk of this material, often constituting more than half of that of the original clay, is a grave disadvantage. A number of applications of the washed and ignited residues have been suggested, including its use either in the preparation of sodium

silicate, in the manufacture of silica brick or crucibles, as a puzzuolanic addition to Portland cement, or as an absorbent (*Zement*, 1934, **23**, 749).

All the aluminium produced in the United Kingdom is obtained from bauxite, most of which is imported from France. No attempts appear to have been made to extract alumina from clay in this country on the commercial scale, but should any of the processes being studied abroad prove successful, there would be the interesting possibility of utilising British clays, such as the kaolin deposits of Cornwall, which are available in large quantities.

Aluminium Powder in Rust-resisting Paints.—The results of experiments carried out in France show that aluminium powder mixed in certain paints gives a product having strong rust-resisting properties.

According to the *Engineer*, November 22, 1935, one of the successful paints contained 62·5 per cent. of pitch, 12·5 per cent. of aluminium powder, and 25 per cent. of a diluent, the best results being obtained when two coatings were applied. Experiments are stated to show that the surfaces protected in this way are not only more resistant, but also more durable than when protected by red lead paints. Moreover, the fluidity of the pitch paints and the opacity due to the aluminium are said to give a covering power two or three times that of red lead paints. In addition to its use for the prevention of atmospheric corrosion, these aluminium paints are being used for the protection of boiler walls in a large power station.

The World's Steel Production.—A review of the world's production of steel based on the returns available for the last six months of 1935 shows that the situation is again becoming normal. The monthly average production rose to more than 8,300,000 tons, which is nearly 25 per cent. above the average for the corresponding period of 1930, and only 10 per cent. below that for 1929. Political and financial considerations, however, together with the extension of the metal industry in the U.S.S.R., have brought about changes in the distribution of production.

While Great Britain produced at a rate about 6 per cent. higher than in 1929, Germany and the Saar produced at about 98 per cent., France at 76 per cent., Belgium at 73 per cent., the U.S.A. at 72 per cent., and Luxembourg at 65 per cent. of the 1929 rate. On the other hand, the Japanese production for the last six months of 1935 was about equal to that for the whole of 1929 and the monthly average of the Russian production rose to more than 2½ times the 1929 rate.

The Nickel Industry in Northern Ontario.—A recent press bulletin issued by the office of the High Commissioner of Canada in London summarises the active development work, costing many million dollars, which is being undertaken by the companies operating for nickel in Northern Ontario. Though present needs are being met with the existing facilities, and no immediate increases in production are contemplated, plans are being made to ensure that metal stocks may be kept sufficient to supply growing industrial requirements.

Both the International Nickel Company, Ltd., and Falconbridge Nickel Mines, Ltd., are increasing their facilities for ore development. The new vertical shaft being sunk by the International Nickel Company at the Creighton Mine is more than half-way down to its objective of 4,250 ft., and is expected to be ready for service by the end of 1936 or early in 1937. It is estimated that it will cost $2,700,000 and its completion will double the hoisting capacity of the mine. The shaft is one of six compartments, of which two will be used for hoisting, two for men and material, one for manway and pipeway, one for ventilation. The capacity of the shaft will be 4,000 tons of ore daily, and the electrical hoisting installation will be one of the largest in the world.

The Frood Mine is said to be hoisting ore at the largest daily rate in its history, and the number of persons employed is the highest ever engaged at the property. Production can be increased at any time, as more than 100 stopes, not all of which are worked at present, have been prepared to deliver ore. At the same time the Company has the Garson, Murray, and Stobie Mines in reserve, one or all of which can be placed in operation as and when desired.

Falconbridge Nickel Mines, Ltd., has nearly completed a new shaft on which its main operations will eventually be centred, thus enlarging its entire scheme of mining. Much other development work is in progress at this mine. On the 1,200 ft. level, the lowest in the mine, a crosscut showed 21 ft. of ore running 1·7 per cent of nickel, the best selection being 5 ft. in width with 2·3 per cent. nickel.

According to the *Metal Bulletin*, December 6, 1935, the International Nickel Co. proposes making an addition to the Copper Cliff smelter, and to instal two reverberatory furnaces and eight converters with the necessary accessory equipment. The company's entire programme is to cost $6,000,000 and is expected to be completed in about a year.

A New Use for Tin.—The use of metallic tin and certain organic tin compounds as catalysts for accelerating the hydrogenation of coal and oil has been announced by Mr. Kenneth Gordon in a paper read before the Institute of Fuel on November

22, 1935. The discovery of these catalysts by Imperial Chemical Industries, Ltd., and allied companies, is regarded as of prime importance, and is claimed to have put the hydrogenation of bituminous coal on a sound practical basis.

Most catalysts which had hitherto been used in the hydrogenation process were affected adversely by various substances or "poisons," such as sulphur, occurring in the materials treated. The removal of such "poisons" was, for economic reasons, not practicable. In 1929, however, it was found that tin is essentially immune from "poisoning," and arrangements were suggested for using the material in the form of tinned iron plates, arranged as a grid. Although these arrangements were successful, they were soon discarded in favour of a continuous injection of small quantities of certain organic compounds of tin, but details have not yet been published regarding their actual composition. It was subsequently discovered that the range of coals which could be successfully hydrogenated was considerably increased by the use of coal cleaning, combined with the use of hydrogen chloride in the reaction vessels. Coal cleaning is beneficial, not only for the obvious reason that it avoids expensive processing of coal ash, but also because the ash is usually alkaline, in which case it has a deleterious effect on catalysis. Hydrogen chloride added as such, or as a compound which forms it, under reaction conditions, neutralises the residual ash, and has a beneficial effect on the hydrogenation reaction itself.

The Recovery of Vanadium at the Rhodesia Broken Hill Plant.—The Broken Hill lead-zinc deposits occur in dolomites and slates, and at the mine most of the ore-bodies occur in massive dolomite within an area of about 1 mile diameter. A feature of the deposits is the depth (100 ft. or so) to which oxidation has taken place. Below the zone of oxidation the veins are composed of a core of lead-zinc sulphides surrounded by a shell of zinc silicate, and between this and the dolomite walls is a zone of broken ground containing hard clay in which the vanadium minerals descloizite and vanadinite occur. Above the 100 ft. level the lead-zinc sulphides are completely oxidised, and vanadium minerals are disseminated through the surrounding soil.

T. R. Pickard, General Manager of the Company working these deposits, has published an interesting account of the extraction of the vanadium and zinc from these ores (*Engng. Min. J.*, 1935, **136**, 489-493). He states that the brown sandy clay of the upper deposits carrying a vanadium content of some 3 per cent., mostly in the form of descloizite, forms the source from which the vanadium ores are at present worked.

The concentration varies, and to maintain an even vanadium content several faces are worked in open cuts.

The ore, as trammed from the mine, is crushed and concentrated on two series of sand tables, and the primary and secondary concentrates with about 10 per cent. V_2O_5 are re-treated on two tables to raise the grade to over 16·5 per cent. Gravity concentration of the vanadium minerals occurring in these deposits is reasonably satisfactory, though the opinion is expressed that better recoveries could be made with adequate regrinding equipment.

Generally, two products result from the ore dressing operations, a 16·5 per cent. concentrate for shipping, and middlings and slime concentrates with about 8·5 per cent. V_2O_5 for further treatment. For production of the fused oxide, the second product of the separation is ground to pass 200 mesh and mixed in a wooden stave tank of 20,000 gals. capacity with sufficient diluted sulphuric acid to give a solution with 30-40 grams of V_2O_5 per litre. Cooling coils in the leaching tank prevent the temperature of the solution reaching 40° C., above which point a partial precipitation of vanadium might occur. To check the reduction of the oxide V_2O_5 to V_2O_4 by absorption of iron from the steel balls in the grinding mill, a small quantity of manganese dioxide is added during the leach. The final solution from this process contains a ratio of free acid to V_2O_5 of about 1 : 2.

The leach may be treated in three ways. In the first the leach is allowed to settle, and the clear solution is decanted, subsequently combined with the liquid from several leach washings, and after filtration, heated to 90° C. After 4 hours at this temperature the precipitation of vanadic hydrate is almost complete; the precipitate is filtered and fused to oxide generally containing above 91 per cent. V_2O_5.

The second method is employed when a percentage of copper and phosphorous is present above the allowable sales limit of 0·05 per cent. The leached solution is neutralised with zinc dross or lime, and the impurities are removed by adding sodium sulphide or excess of soda-ash. The precipitate is filtered off, the solution acidified, and the hydrate precipitated in the usual manner.

Instead of decanting the leach, in the third method it is neutralised and treated with soda-ash or sodium sulphide in the original tank. The pulp is then filtered and the filtrate acidified and treated as in the other two methods.

The Use of Magnesite-Talc Rock from the Sudan as a Refractory and the Development of Forsterite-Periclase Bricks.—In view of the limited available supplies of the purer types of magnesite, the introduction to the refractories industry from

the Sudan of lower grade material which, it is claimed, yields refractory bricks of good quality, is a matter of some importance.

The material concerned occurs as large masses in an area where ancient serpentines have been altered by the action of solutions carrying carbon dioxide ("On an Area of Ultra-basic Rocks in the Kassala Province of the Anglo-Egyptian Sudan," by W. H. Wilcockson and W. H. Tyler, *Geol. Mag.*, 1933, **70**, 305). One such mass forms a hill 400-500 ft. in height, has a length of 2 miles, a width of $\frac{3}{4}$ mile, and is only $1\frac{1}{2}$ miles from the railway station of Quala en Nahl, 500 miles from Port Sudan on the Kassala branch of the Sudan Government Railways.

The rock consists of breunnerite, a variety of magnesite containing several per cent. of ferrous oxide, in a ground mass of talc, together with a little accessory chromite, or picotite, and magnetite ("An Investigation into the Commercial Utility of a Deposit of Magnesite-bearing Rocks in the Anglo-Egyptian Sudan," by W. H. Tyler and W. J. Rees, *Trans. Ceramic Soc.*, 1934, **33**, 104-127). The chemical and mineralogical composition of two samples was as follows:

	A.	B.
SiO_2	31·43	20·16
Al_2O_3	2·53	2·27
FeO	4·50	6·30
MgO	35·44	36·35
CaO	0·37	0·30
Cr_2O_3	0·37	0·89
Loss on ignition	24·60	33·60
Alkalis	n.d.	n.d.
	99·24	99·87

	A.	B.
Talc	49·5	33·0
Magnesite	41·5	55·0
Other Constituents	9·0	12·0
	100·0	100·0

The point of interest about this rock is that instead of the talc being a deleterious constituent it promises in this instance to afford considerable benefits, for if the magnesite and talc can be made to interact and their proportions are properly adjusted, they will form a magnesium silicate (forsterite).

Forsterite is a particularly valuable refractory having no inversions from room temperature to its melting point of 1,910° C. and a remarkable resistance to crushing under load at high temperatures. Whereas fused pure magnesia (periclase) crushes under a load of 66·5 lb. per sq. in. at 1,690° C., a fused product containing an addition of silica so that the periclase grains are cemented by forsterite does not fail under the same load until a temperature of 1,870° C. has been reached.

Difficulties which have been encountered in the use of forsterite as a high-temperature refractory are: (*a*) the naturally occurring forsterite is always too intimately mixed with certain undesirable minerals to render its use possible,

and (*b*) the preparation of artificial forsterite from silica and magnesia has been commercially impracticable on account of the high temperature required in order that complete reaction could take place.

The use of a mixture of natural magnesium silicates containing a higher silica content than forsterite and the requisite amount of magnesite, heated to a temperature around 1,550° C., affords the most promise. Recognition of this fact is afforded by recent attempts in America to prepare forsterite bricks by enriching a low-iron magnesian olivine with magnesia (" Forsterite and other Magnesium Silicates as Refractories," by R. E. Birch and F. A. Harvey, *J. Amer. Ceramic Soc.*, 1935, **14**, 176-192). In this case the presence of talc and serpentine as accessory minerals in the raw material does not matter, for they, too, are converted to forsterite on addition of the required amount of magnesia.

Tests have been made by Tyler and Rees on 5 tons from the largest outcrop of the deposits in the Sudan (Analysis A). Mixtures were made of the raw Sudan rock and dead-burnt, non-ferruginous, Grecian magnesite. The minimum shrinkage occurred with equal parts of the two when the linear shrinkage was rather less than 1 per cent. Taking both refractoriness and firing shrinkage into account, it was found that mixtures within the limits of 100 parts Sudan rock to 20 parts Grecian dead-burnt magnesite and 100 parts Sudan rock to 100 parts Grecian dead-burnt magnesite can be considered as possible for use in the manufacture of high temperature refractories.

Mixtures of equal parts of Sudan rock and Grecian dead-burnt magnesite were used for a detailed investigation. It was inferred that sound bricks can be made with little modification of the technique now used for the manufacture of magnesite bricks. The bricks are bonded by a material with a sufficiently low temperature of reaction to do its work during the brick-making, but which during this process itself becomes highly refractory. This obviates the necessity of adding bonds with a low melting point which may decrease the refractoriness of the finished product.

The strongest briquettes were found to be those in which rims of forsterite had developed around the periclase grains. It is stated that the ideal method to adopt in making bricks from the material is to mix the Sudan rock as an impalpable powder with an amount of the finely powdered dead-burnt magnesite (about 8 per cent.) which will be just insufficient to make a mixture forming forsterite on calcination, and to add this to dead-burnt Grecian magnesite so graded that the complete mixture approximates as nearly as possible to that found most desirable in the finished bricks. In firing such a mixture fusion will take place at as low a temperature as

possible and magnesia will be taken up from the large grains which will be drawn together on cooling. This surface attack promotes the rim structure around the periclase grains and gives strength to the finished bricks. Although at 1,500° C. the strength of periclase vanishes, the forsterite bond enables the brick to withstand higher temperatures and pressures than an ordinary magnesite brick.

The bricks are reported to have been exhaustively tested in steel furnaces in various parts of this country with such success that a leading dolomite company in England has erected a plant for their manufacture at the rate of 6,000 bricks per week in order that they may be tried on the market for one year. For this test about 500 tons of the Sudan rock are being imported.

The use of an impure magnesite requiring no dead-burning, and therefore more easily ground, as a substitute for 50 per cent. of the dead-burnt magnesia ordinarily used, suggests a definite saving on production costs. The large extent and conditions of occurrence of the Sudan deposits suggest that mining costs will probably be low, and if reasonable transport charges can be obtained, it should be possible to bring the material to British ports at something less than £4 per ton. The present London price of dead-burnt Grecian magnesite is around £7 10*s*. per ton.

Zircon Sand in New South Wales.—During 1934-5 the zircon-rutile-ilmenite sands along the sea coast near Byron Bay were worked by Zircon-Rutile, Ltd., who claim to have perfected a flotation process for separating zircon from rutile. It now appears that a new concern, Zircon Mining Co., Ltd., is taking over a lease of 88 acres of Crown land at the mouth of Clarence River, Yamba. According to *Mineral Trade Notes, U.S.*, November 1935, this company is a subsidiary of an American consumer of zircon with works at Niagara Falls, and about 85 tons of zircon sand are being recovered per month and shipped to the United States for further treatment. The heavy minerals are derived from old raised beaches which have been cut into by the sea, the minerals being concentrated by wave action, especially during storms.

Quartz Crystals for Radio Oscillators and Sound Resonators.—Brazil is the source of most of the quartz crystals used both in the United Kingdom and in the United States for the manufacture of radio oscillators and sound resonators; although this Institute has for many years sought for a suitable and reliable source of supply within the Empire, none has so far been forthcoming.

In this connection it is interesting to note that according

to *U.S. Bur. Mines, Mineral Trade Notes*, November 1935, the U.S. Naval Gun Factory has lately been using 700 lb. of quartz crystals per annum, as well as small amounts of fused quartz of the finest optical quality. The specification for quartz crystals for use at the Naval Gun Factory is stated to be as follows: "The crystals shall be of a minimum weight of 3 lb. and shall be free from internal inclusions, fractures or other defects and shall have at least two natural side faces with growth lines thereon. Crystals shall not be less than 3 ins. and not more than 12 in. in diameter at the largest end. This is to preclude long, thin crystals which may weigh over 3 lb., but which are not suitable for the intended purpose. Crystals shall be so formed that the area of one side face shall not be less than 4 sq. in. in order to permit the proper mounting in holders for the cutting operations."

Base-exchange Water-softeners.—For some years work has been in progress at the Water Pollution Research Board's laboratories on the water-softening properties of certain commercial brands of base-exchange materials. A summary of the results appears in the recently published *Annual Report* of the Board for the year ended June 30, 1935.

The materials investigated were (*a*) a relatively porous natural mineral similar in structure to granulated brick, (*b*) a treated glauconite sand, and (*c*) a synthetic material consisting of a porous gel. The first two are imported into Great Britain, and the third is manufactured here.

It was found that using Teddington tap water, which has a hardness of 25 parts per thousand, due mainly to calcium bicarbonate, and maintaining a flow of 70 gals. per hour per cu. ft. of material, the synthetic substance (*c*) had an exchange value more than 1½ times that of the porous mineral (*a*), and 2½ times that of the non-porous mineral (*b*), compared on a basis of equal volumes. Using equal weights, the exchange value of (*c*) was 2½ times that of (*a*) and 5 times that of (*b*). On increasing the rate of flow of the hard water it was found that the exchange value of the synthetic material decreased progressively, but that there was little or no effect on the values of either the non-porous mineral or the porous mineral within the range of 60 to 200 gals. per hour per cu. ft.

As regards regeneration with salt solutions, it was found that, provided ample time is allowed for contact with the brine and the quantity of salt is above a certain minimum per cu. ft. of material, the exchange value of the regenerated material is independent of the strength of brine in the range of 2·5 to 20 per cent. However, it appeared that increase in time of contact between brine and synthetic material markedly

increased the exchange value of the latter but had little effect on the natural minerals.

As regards the important matter of resistance to disintegration, experiments showed that non-porous minerals and certain synthetic substances were more satisfactory in this respect than porous minerals. Another conclusion reached is that the base-exchange values of porous and non-porous natural minerals are about the same for solutions of magnesium sulphate as for calcium sulphate and the Teddington tap water, but that the synthetic material is much less suitable for removing magnesium salts than for calcium salts. Further experiments have shown that the base-exchange materials employed were capable of removing all traces of lead, copper, zinc, and tin from drinking water (except copper in the presence of citric acid), but it is necessary to use sodium nitrate in place of common salt for regeneration when lead has been absorbed.

A most important feature of the work carried on in the Board's laboratories in recent years has been concerned with the preparation of materials suitable for base-exchange water softening from British clays. The process consists in treating the clays with strong hydrochloric acid or sulphuric acid, drying and grading the product and then heating it in an oxidising atmosphere at 550° to 600° C., finally treating it with solutions of sodium silicate and sodium aluminate. The process has been patented in the names of W. H. Sullivan, H. Ingleson, and B. A. Adams (E.P. 434,663 of 1934). From some clays, particularly fuller's earth, materials have been prepared which have base-exchange values equivalent to about 0·5 lb. CaO per 100 lb. of material, and which are more resistant to disintegration than imported porous minerals.

The Coloration of Glass.—The colours seen in coloured glass of all types are almost always due to inorganic or mineral compounds, and are amongst the most permanent known. An enormous variety of shade and intensity of colour is obtainable by variations in the materials used. It has been stated that in the Vatican Studios in Rome, where glass mosaics are made, as many as fifty thousand colour tones in glass are available. The final colour is affected, not only by the actual colouring agent used, but also by the type of glass and by the treatment to which it is subjected, reheating of the glass after removal from the melting furnace being essential in many cases.

A large number of colouring agents have been used at various times for special colours in glass (Silverman, *J. Franklin Inst.*, 1935, **220**, 552). Red glass was first produced by the use of copper compounds. This glass, when first removed from the furnace, is amber, and develops a red

colour upon reheating. Gold compounds have also been employed; these produce a yellow to amber colour at first, and upon reheating the colour becomes a deep ruby. In this case the colour is actually due to the presence of colloidal particles of gold. More recently red glass has been produced by the use of selenium. This again gives an amber colour, which on reheating is converted to deep ruby red. Selenium red glass has the advantage that the colour remains uniform with varying thickness of the glass, and the amount of light transmitted is high. Consequently selenium glasses are useful for traffic signals. Copper reds can be produced in either lime or lead glasses, but selenium reds are very sensitive to the composition of the glass (Bowmaker, *J. Soc. Glass Tech.*, 1935, **19**, 40). It has been suggested that this may be due to the ready volatility of selenium, which may be affected by the viscosity of the melted glass, the viscosity varying with the composition.

Amber glass is produced by the use of charcoal, usually with sulphur or sulphur compounds. Yellows are made with various foundation glass mixtures by the use of silver or uranium compounds. The silver compounds give a true canary yellow, while uranium glasses tend to have a slight greenish fluorescence. On an experimental scale, a very fine clear yellow glass is said to be produced by the use of indium sesquioxide in a mixture containing sulphur (Murray, *Industr. Engng. Chem., Industr. Ed.*, 1934, **26**, 903).

Green shades are produced by iron compounds, and these are usually avoided in the better kinds of glass, either by the use of iron-free raw materials, or by the addition of decolourising agents. Deep olive green colours are obtained by the use of chromium compounds. With black oxide of copper under oxidising conditions, a large range of blues can be produced, while cobalt compounds give deep rich blue tones. By suitable mixtures of substances which produce greens and blues almost any desired shade can be obtained.

Manganese dioxide gives amethyst colours, and the newer pale amethyst or wistaria shade is said to be obtained by the use of neodymium compounds. By employing sufficient quantities of either manganese or neodymium compounds purple colours are produced. Purple can also be obtained by the use of gold.

As a rule, so-called black glasses are not truly black, as in front of an intense source of light they appear purple. Black glass is produced when a sufficiently large quantity of a substance like manganese or cobalt, which gives an intense purple or blue colour, is used.

Almost any colour or shade can be produced by regulating the amount of colouring agent and the composition of the glass.

Calcium Carbide.—According to the Scottish correspondent of the *Chemical Trade Journal*, as reported in its issue for December 6, 1935, the British Oxygen Co., Ltd., proposes to erect a plant at Corpach, near Fort William, for the manufacture of calcium carbide. At present this important material does not appear to be made in the British Isles, and British requirements, amounting to between 40,000 and 45,000 tons a year, are met by imports, principally from Norway.

New Building and Public Works Laboratories in Paris.—The systematic examination and testing of materials used for building construction has long passed out of the preliminary stage, and, except in primitive communities, most constructional materials, including paints and other products used for decoration, are subject to more or less stringent tests, either by the manufacturer, the user, or some independent body set up for that purpose. In certain cases the reasons for failure or deterioration under specified conditions are also investigated.

In this country the Building Research Station has, for a number of years, undertaken work of this nature, and their results, and the expert advice they are able to give, have proved of great value to various branches of the building trade and allied industries. The Imperial Institute also has, in its ceramic laboratory, carried out extensive tests on a considerable number of Colonial clays, and has been able to advise on their suitability for the local manufacture of bricks and tiles, or to suggest how primitive native methods of manufacture could be amended in order that superior products might be obtained.

Prior to 1935 France did not possess any central organisation for the testing and study of the properties of constructional materials, but in that year Building and Public Works Laboratories were opened in Paris by M. Edouard Herriot, President of the French Association for the Development of Technical Education, and a full description, well illustrated by photographs, is given in a special number of the French review, *L'Entreprise Française*, November 1935.

It would appear from the description given in that publication that France will no longer be dependent on other countries for research work in constructional materials, for the new laboratories just opened appear to be admirably equipped for the examination and testing of everything used in building. Their activities are intended to cover a wide field, and they are able to carry out comprehensive tests relating to the mechanical strength, composition, physical, and chemical properties of such varied materials as metals, alloys, concrete, cement and other hydraulic materials, sands, aggregates,

bricks, tiles, lime-sand bricks, refractory materials, glass, water, oils, paints and varnishes, fuels, rubber, bitumen, heat and sound insulating materials, etc.

Provision has also been made for the study of the mechanical properties of soil, with particular reference to its suitability for foundations.

RECENT RESEARCH ON EMPIRE PRODUCTS

A Record of Work conducted by Government Technical Departments Overseas

AGRICULTURE

SOILS

Trinidad.—The following statement of work carried out by D. W. Duthie is taken from the Report of the Department of Chemistry and Soil Science, Imperial College of Tropical Agriculture, for the period January to June 1935:—

(1) *Forest Soil Research.*—The soil deterioration experiment in the Arena Reserve Plantation has now reached a stage when it is advisable to summarise the results to date. Consequently, it is proposed to prepare a joint report with Mr. R. L. Brooks, Conservator of Forests, in which the results will be critically examined. In general, the findings have provided strong support of the accepted views, namely, that opening up of forest land causes greatly increased temperature and humidity fluctuations and that there is a definite loss of leaf litter and organic constituents of the topsoil. But the changes observed (particularly in the mineral fraction of the soil), are not sufficient to account for the drastic alteration of sylvicultural characteristics and it is possible that a more detailed study of the litter and surface layers of the soil may be more informative. The main object in the past has been to obtain as much general information as possible and it is now necessary to consider how far these have been successful in indicating those factors which should be studied in greater detail.

(2) *Soil Organic Matter Investigations.*—The laboratory studies carried out during the past 3½ years have yielded a mass of evidence which seemed to be conflicting in many respects and the figures were studied with a view to finding some general principles which would explain the anomalies. The methods employed were adapted from Waksman's

simplified fractionation method, which appears to be widely used at the present time. A great difficulty in interpreting the results lies in the fact that they do not entirely agree with the present ideas of the chemical nature of soil organic matter. In temperate climates, the C/N ratio seldom drops below 10, and theories have been postulated on the assumption that this is the end-point of the decomposition processes where the transformations have followed a normal course. There is thus no explanation of ratios as low as 5 or 4, which are commonly found in tropical soils. Some sort of combination of lignin and microbial protein was believed to form a relatively stable complex, but, so far as the present investigation has gone, there is no evidence of stability in the transformations and the main principle involved seems to be a steady decomposition of the different plant compounds at various speeds. Carbohydrates decrease very rapidly and the nitrogen changes are also relatively rapid, although their exact nature is far from clear. Lignin is not so resistant as it has been found to be in temperate climates and the evidence suggests that there is a continuous, slow decomposition of lignin, resulting in its complete disappearance in extreme cases.

These considerations are largely hypothetical at present, but they serve a useful purpose in indicating lines of work which seem to be most profitable. It is probable that the nitrogen compounds reflect the biological changes and some success has been obtained with fractional hydrolysis of the nitrogen compounds. In view of this, it is proposed to continue the intensive study of the nitrogen transformations.

Plant Diseases

General

Gold Coast.—The Director of Agriculture, in his report for the period July to December 1935, states that some new plant diseases were recorded for the first time on material imported into the Gold Coast from abroad. The most important were tobacco leaf curl, sugar-cane leaf streak and citrus scab. Tobacco leaf curl was imported in seed of "Bourbon" tobacco from Mauritius, sugar-cane leaf streak on canes imported from South Africa and citrus scab also on material from South Africa. Energetic control measures are being taken, and the sugar-cane leaf streak has been eradicated.

Beverages

Cacao

Gold Coast.—According to the report of the Director of Agriculture for the period July to December 1935, four

shipments of Dasyscapus parasites of thrips have now been made to the Government of Trinidad, where thrips attack is extremely severe. These minute insects have to be sent in their pupal stage, provision being made in the containers for the adults to feed as they emerge from the pupæ. The pupal stage lasts on an average for 10 days and adults will only live 4 to 5 days in captivity. A maximum of 15 days can therefore be allowed for transit from the Gold Coast to Trinidad. This can only be accomplished when the mail steamers from Accra establish connection with the weekly German trans-Atlantic air mail from Bathurst to Brazil, whence there is a good air service to Trinidad.

In the first and third shipments the steamers arrived after the air mail had left and a week's delay occurred at Bathurst. In both these consignments the insects were dead on arrival. The second shipment, however, caught the air mail and 208 insects were alive on arrival. In the last shipment there was no hope of establishing connection with the Bathurst air mail, as the day of departure had been changed. The entomologist, therefore, sent the containers in cool storage, in the hope that this would prolong the pupal stage for a sufficient time to make up for the delay. Results of this shipment are not yet to hand. No further shipments will be possible till August 1936 as thrips (on which the parasite preys) infestation locally is falling rapidly in the collecting area.

The Trinidad authorities report that they are successfully breeding up from the stock received by the second shipment and that if they get a further stock alive from the fourth shipment it may not be necessary to send more.

Trinidad.—The Report of the Department of Chemistry and Soil Science, Imperial College of Tropical Agriculture, for the period January to June 1935, contains the following account of work on cacao research carried out by J. A. McDonald, F. Hardy, and G. Rodriguez.

(1) *Manurial and Mulching Experiments.*—The period January to June covers the dry season in Trinidad. This is the time when the bulk of the cacao crop is reaped and is also the most suitable time for the application of artificial manures to cacao fields. There are now twelve different field experiments being carried out by the Chemical Section of Cacao Research, which include 500 individual plots to which separate manurial treatments are applied during the dry season. There are a total number of 5,400 cacao trees in these experiments, from which individual yield records are taken at each picking. These yield records include, not only the

number of pods from each tree, but also the weight of wet cacao from each plot, so that accurate data may be available concerning the quality of the cacao (size of bean), as well as the quantitative yield. Each experiment is picked, on an average, once per month during the dry season, so that the operation of obtaining yield records occupies a large amount of time during this period. It is apparent, therefore, that the bulk of the work carried out by the Chemical Section during the past six months has consisted of field work in connection with the various manurial trials and mulching experiments. The field experiment takes prior place in the present and contemplated future researches, since it forms the basis of other lines of research previously described. Each experiment has been designed to test a definite problem suggested by previous investigations, and the effects of manuring or mulching are assessed, not only by records of yield increments, but also by chemical analysis of the leaves and other parts of the cacao tree and by a systematic study of the effects produced by the manuring on the physical and chemical properties of the soil.

(2) *The Chemical Composition of the Cacao Tree.*—Good progress has been made in the investigation of the effect of manurial treatments on leaf composition of cacao and detailed results have been published in the *Fourth Annual Report on Cacao Research.* The results show that a close relationship exists between cacao leaf composition and quantitative yield of individual plots. High yield is associated with a high potash content of the leaf relative to nitrogen and phosphate and a low phosphate content of the leaf relative to nitrogen and potash. As an index of nutrient supply, the chemical composition of cacao leaves may be best represented by four main factors, the optimum numerical values of which are approximately (1) total ash, 9·9 per cent. of dry matter; (2) nitrogen/potash ratio, 0·89; (3) nitrogen/phosphate ratio, 4·66; and (4) potash/phosphate ratio, 5·21. This standard leaf composition indicates an adequate and balanced nutrient supply, resulting in maximum yield from mature cacao trees.

Changes in leaf composition show that, at this site, potash manure alone has been beneficial and has resulted in a more balanced nutrient supply to the trees. Nitrogen alone and phosphate alone have been ineffective, but these two elements applied in combination have caused the nutrient supply to become even more unbalanced than that of the control plots. The effects of manurial treatments on leaf composition closely agree with the effects of manurial treatments on yield of cacao.

The results obtained for cacao growing on this potash-deficient soil have been compared with the results of previous investigations of cacao growing on an experimental site where *phosphate* is markedly deficient in the soil. The collected results indicate that mature cacao trees require adequate supplies of potash for greatest growth and yield. A shortage of potash in the plant may occur, either as a result of soil potash deficiency, or as a result of soil phosphate deficiency, the latter condition being of much more widespread occurrence in West Indian cacao-growing areas.

(3) *Sand Culture Experiments.*—A new series of sand culture experiments has lately been initiated to provide information on the gypsum-phosphate problem in cacao soils. In this series, the cultures have been divided into four groups receiving the following nutrient treatments, (I) high potash and high calcium, (II) high potash and low calcium, (III) low potash and high calcium and (IV) low potash and low calcium. With each group four separate treatments are applied, (1) low sulphate and low phosphate, (2) low sulphate and high phosphate, (3) high sulphate and low phosphate and (4) high sulphate and high phosphate. There are thus sixteen different treatments, each of which is triplicated. The effects of high calcium-ion and high sulphate-ion, both separately and together, are being tested at high and low phosphate concentrations. The possible reciprocal effect of potash and calcium is also being tested. In addition to growth observations, it is intended that the experiment should provide leaf material for chemical examination in an attempt to trace the effect of the different nutrient solutions on the nutrient absorption processes of the plant.

SUGAR

Cane

Trinidad.—The following statement relating to experiments on sugar-cane soils, carried out under the supervision of P. E. Turner, is contained in the Report of the Department of Chemistry and Soil Science, Imperial College of Tropical Agriculture, for the period January to June 1935.

(1) *Germination of Setts Experiments.*—Measurements have been made of the effect on germination of sugar-cane setts under field conditions, of dressings of sulphate of ammonia, superphosphate and sulphate of potash, applied at the time of planting, in the presence and absence of ground limestone. The results obtained may be summarised as follows.

(*a*) In certain circumstances, dressings of sulphate of ammonia at planting, can exert an adverse effect on the germination of sugar-cane, as measured by the number of supplies required under field conditions.

(*b*) The adverse effect of sulphate of ammonia can become more serious as the size of the dressings is increased.

(*c*) Previous treatment of the soil with ground limestone can exert a favourable effect on germination and can reduce the adverse effect of sulphate of ammonia.

(*d*) When superphosphate, sulphate of potash, and limestone are applied in combination, the effect of each manure on germination appears to be independent of the presence of the others.

(2) *Formation of Tillers.*—A study has been made of early tiller formation of sugar-cane, in relation to manurial treatment. It has been shown that :—

(*a*) The number of early tillers formed by a stool of plant canes, on the average, can be increased by 40 per cent. by treatment of the soil with ground limestone, by as much as 70 per cent. with sulphate of ammonia and by 10 per cent. with sulphate of potash. Phosphate appears to be of importance only in the presence of other manures.

(*b*) Dressings of lime and nitrogen in combination lead to greater tiller formation than either manure alone, but the average increase in the number of tillers due to lime is significantly less in the presence of high dressings than of low dressings of nitrogen. To obtain maximum tillering in the presence of lime and high nitrogen, treatment with potash is required in addition.

(*c*) Dressings of lime and potash, when applied together, both appear to exert their own independent effects on tillering. Phosphate depresses the effect of lime on tillering, but this adverse effect of phosphate can in part be counteracted by treatment with potash. So far as the three manures, lime, potash and phosphate, are concerned, greater gain in tillering appears to result from applying lime and potash only than from applying phosphate with lime and potash.

(*d*) The effect of high nitrogen and potash, when used together, is greater than the sum of their independent effects. Phosphate can profoundly increase the average beneficial effect of potash in the presence of high nitrogen. So far as the three manures, nitrogen,

phosphate and potash, are concerned, much greater gain results from applying phosphate with high nitrogen and potash, than from applying high nitrogen and potash only.

(*e*) The measurements were made on the plots of two field experiments. In one of these experiments, the use of a manure containing lime, nitrogen and potash, increased the average number of tillers to the stool from 3·4 to 13·3. In the second experiment, phosphate, potash and an additional light dressing of nitrogen, increased the average number of tillers to the stool from 9·6 to 10·9. The soil of the latter experiment is more fertile than that of the former. In addition, all plots of the second experiment received a basal dressing of nitrogen.

Root Crops

Cassava

Gold Coast.—According to the report of the Director of Agriculture for the period July to December 1935, some fairly encouraging results have been obtained in the attempt to breed types of cassava resistant to mosaic disease. Some 3,830 controlled cross-pollinations have now been made, from which 435 fruits have been obtained. From these fruits 95 seedlings have been produced, of which 36 are over 9 months old. No natural infection of mosaic has been recorded in these 36, and 12 of them have remained free from attack after artificial infection by budding from infected stock. Though artificial infection cannot be taken as a critical field performance, it affords a useful indication of extreme susceptibility. In such small field trials as were possible with limited planting material as Aburi, a different centre from the place where the seedlings were bred, ten have so far remained immune from the disease, and of these ten, four were also resistant to artificial infection where bred. The work is being continued on a larger scale as more material becomes available and the yields and palatability of the new varieties are being studied.

Fruits

Citrus

Trinidad.—The Report of the Department of Chemistry and Soil Science, Imperial College of Tropical Agriculture, for the period January to June 1935, contains the following statement relating to work on citrus research carried out by F. Hardy and G. Rodriguez.

(1) *Lime Requirements* of surface soils collected in the grapefruit soil survey have been determined by two methods: (*a*) the Hardy-Lewis electrometric method (which assesses lime requirement to a definite *p*H value) and (*b*) a standard base-exchange method (which assesses lime requirement to a definite degree of saturation by absorbed calcium). The results have demonstrated a general low degree of lime saturation in the grapefruit soils of Trinidad.

(2) *Chemical Analysis of Grapefruits.*—In view of the suspected importance of calcium in the cultivation of grapefruit, an attempt was made to trace the effect of a lime-saturated soil, as compared with a lime-deficient soil, on the quality of the fruit, as revealed by chemical analysis. At the same time, an attempt was made to discover whether commercial grading (which is based in size, shape and discoloration of the fruit) bears any relationship to chemical composition of fruit. Certain definite differences were obtained.

The results of these grapefruit investigations have been reviewed in an article published in *Tropical Agriculture* (1935, **12**, 205).

FIBRES

Silk

Gold Coast.—The Director of Agriculture, in his report for the period July to December 1935, states that ten generations of the eri silk-worm (*Attacus ricini*) have now been bred at Aburi from the first seed eggs imported from India and they appear to have acclimatised themselves to local conditions at Aburi. Provided there is no overcrowding, mortality is extremely low. An attempt was made to substitute cassava as a food plant instead of castor, but it had a deleterious effect on development and the quality of the silk and was discontinued. A sample of locally-produced cocoons was sent to the Imperial Institute and received an encouraging report, though the price payable in home markets is at present too low to encourage production locally for export. Local spinning and weaving trials are being conducted with the silk.

MINERAL RESOURCES

CYPRUS

The Imperial Institute has received from the Inspector of Mines and Labour the following report on mining activities in Cyprus during the last six months of 1935.

The steady increase in the output of cupriferous pyrites

was maintained for the period under review, attributable to the greater capacity of the new metallurgical plant at Xero and a satisfactory demand for crude pyrites and concentrates by overseas markets.

There was a falling off in the production and export of asbestos during the latter half of 1935, in consequence of increasing difficulties experienced by the Cyprus and General Asbestos Co., Ltd., in marketing its fibres. As a result, less labour was employed at the mine.

Greater activity was shown in prospecting during the period under review, the exploitation of auriferous ore at Skouriotissa having drawn attention to the possibilities of gold mining in the Colony. A number of prospecting permits were issued, and the discovery of gold has been reported from several districts. Although results are said to be encouraging, there is, as yet, no evidence of the existence of very extensive deposits.

Work done by the Cyprus Mines Corporation at the Skouriotissa Pyrites Mine

	Last 6 months 1935.	Last 6 months 1934.
Underground development, footage	274	418
Tonnage mined	69,082	30,853
Underground labour (average per day)	735	585
Tonnage exported	62,817	43,811
Labour, surface and underground (average per day)	1,508	1,136

Work carried out at the Mavrovouni Pyrites Mine of the Cyprus Mines Corporation

	Last 6 months 1935.	Last 6 months 1934.
Underground development, footage	6,668	8,375
Tonnage mined	138,407	66,703
Underground labour (average per day)	1,074	460
Tonnage exported	70,050	14,381
Cement copper exported, tons	170	nil
Labour, surface and underground (average per day)	1,725	1,234

Work done at the Lymni Mine of the Cyprus Sulphur and Copper Co., Ltd.

Operations were suspended for the period under review.

Work done at the Troodos Mines of the Cyprus Chrome Co., Ltd. (Mining Lease and Prospecting Permit areas)

	Last 6 months 1935.	Last 6 months 1934.
Development, total footage	771	1,445
Tonnage mined	974	846
Tonnage exported	nil	nil
Labour (average per day)	41	48

Work done by the Cyprus Mines Corporation, Skouriotissa, in the production of "Devil's Mud" (auriferous andesite)

	Last 6 months 1935.	Last 6 months 1934.
Underground development, footage	8,015	12,292
Ore mined, short tons	10,527	4,342
Ore exported, short tons	nil	2,524
Gold content of ore exported, troy oz., fine	*	10,488
Silver content of ore exported, troy oz., fine	*	70,143
Gold-bearing metallic precipitate exported, tons	nil	3½
Gold content of above metallic precipitate, troy oz., fine	*	2,604
Silver content of above metallic precipitate, troy oz., fine	*	20,194

**There are no figures available of the precious metal content, no exports having been made for the period.*

Work done by the Cyprus and General Asbestos Co., Ltd., Amiandos (formerly Cyprus Asbestos Co., Ltd.)

	Last 6 months 1935.	Last 6 months 1934.
Rock mined, tons	340,862	303,851
Rock treated, tons	73,945	68,546
Asbestos fibre produced, tons	3,722	4,338
Asbestos fibre exported, tons	3,221	4,000
Average daily labour (quarries only)	433	580
Average daily labour (all operations)	775	1,036

Work done by the Hellenic Co. of Chemical Products and Manures, Ltd. (Lease on Troodos)

Operations were suspended during the period under review.

Minerals exported other than those dealt with above were as follows:

	Last 6 months 1935.	Last 6 months 1934.
Gypsum, calcined, tons	2,212	3,107
Gypsum, raw, tons	5,898	100
Stone, building, cu. yds.	2	34
Stone, pumice, tons	1,056	965
Terra umbra, tons	3,579	2,048
Terra verte, tons	3	nil

The following table shows the production and export of certain minerals for the year 1935:

	Production.	Export.
Chrome iron ore, tons	1,179	nil
Copper, metallic, tons (*a*)	12,232	12,232
Gypsum, calcined, tons	—	5,480
Gypsum, raw, tons	16,000	8,741
Gold, troy oz., fine	(*b*)	6,872
Silver, troy oz., fine	(*b*)	44,536

(*a*) *Estimated copper content of cupriferous pyrites and concentrates.*
(*b*) *Figures not available.*

GOLD COAST

The Imperial Institute has received the following statement from the Director of the Geological Survey regarding the work carried out during the half-year ended December 31, 1935.

During the greater part of the period under review the Director and geologists were either on leave or engaged in research work on the material collected during the previous

field tour. One geologist was in the field for three months, and the Director and another geologist for about one month each.

Field work was confined to the examination of several gold mines and prospects in the Wasaw and Ahanta-Nzima Districts; the detailed geological mapping of the Tarkwa goldfield and of the country to the south-west, west and north-west; and to the investigation of the diamondiferous areas near the Bonsa river south-west of Tarkwa.

The Bonsa diamond field, which is some 14 miles long, and one to four miles wide, lies close to the motor road from Tarkwa to Simpa. The district was prospected about five years ago by mining companies, but no deposits were found of sufficient size and value to justify the erection of treatment plants. The alluvial deposits can be worked profitably, however, by native methods, and at the present time nearly 1,000 Africans are engaged in winning diamonds from the gravels of streams draining into the Bonsa river.

The gravels average about 1 ft. in thickness and the overburden 2 to 3 ft. Shallow pits are sunk to the gravel which is extracted and washed in wooden calabashes. The method is simple and rapid, but only about 60 to 70 per cent. of the diamonds in the ground washed are recovered. A good deal of gravel remains untreated owing to the haphazard methods used in siting pits and working the deposits.

Production of diamonds started on a small scale in 1933 and is now averaging about 7,000 to 8,000 carats per month. The diamonds are of average Gold Coast size and quality.

The underlying rock in practically all of the workings is the Kawere conglomerate, the basal member of the Tarkwaian system, but some diamonds also occur in streams draining Upper Birrimian rocks, and the Kawere conglomerate in this area is composed largely of pebbles of Upper Birrimian rocks.

The concentrates consist chiefly of staurolite, limonite, schorl, zircon, kyanite, ilmenite, magnetite, rutile and gold, together with scanty corundum (including deep blue sapphire) and pleonaste.

Bulletin No. 7, "The Bauxite Deposits of the Gold Coast," is now ready for publication, and two other *Bulletins*, one on the geology of Lake Bosumtwi, Ashanti, and the other a bibliography of Gold Coast geological and mining literature, will probably be published in 1936.

Two papers on the diamond deposits of the Gold Coast and the Nsuta manganese ores, respectively, were read by the Director at the seventh session of the International Congress of Mines, Metallurgy and Applied Geology held in Paris in October 1935, and at the request of the Bureau D'Études Géologiques and Minières Coloniales he prepared an article on the geology and mineral resources of the Gold Coast.

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(see also Refractories)

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NOTICES OF RECENT LITERATURE

Books for review should be addressed to "The Editor," Bulletin of the Imperial Institute, South Kensington, London, S.W.7.

THE SOUTH AND EAST AFRICAN YEAR BOOK AND GUIDE FOR 1936. Edited for the Union Castle Mail Steamship Co., Ltd., by A. Samler Brown, F.R.Met.S., and G. Gordon Brown, F.R.G.S. Pp. lxvi + 1,125, 7 × 5. (London: Sampson Low, Marston & Co., Ltd., 1936.) Price 2*s*. 6*d*.

This is the forty-second annual issue of a very excellent handbook which has been previously noticed in this BULLETIN. As a compendium of useful information on South and East Africa from the point of view of agriculture, commerce and industry, geography, history and travel, it can be strongly recommended to all interested in the widespread territories with which it deals. The mass of information furnished in the volume may be judged from the fact that it contains over 1,100 pages of closely printed matter, a large portion of which deals with the Union of South Africa, but which also covers the East African countries, as well as part of Angola and the island of Mauritius.

For the special assistance of tourists and other visitors in their travels there are separate descriptions of 53 travel routes, covering the principal centres of interest in South Africa, the East African countries and the Sudan. At the end of the volume is an excellent series of general and sectional maps, which materially add to the utility of the work.

SOVIET GEOGRAPHY. The New Industrial and Economic Distributions of the U.S.S.R. By N. Mikhaylov. Pp. xviii + 232, $8\frac{3}{4} \times 5\frac{3}{4}$. (London: Methuen & Co., Ltd., 1936.) Price 10*s.* 6*d.*

This is a concise, clearly written, and practical account of industrial and economic development in the Soviet Union, illustrated by useful outline maps and statistical tables. The principal chapters are entitled respectively "The Discovery of New Nature"; "The New Distribution of Industry"; "The New Distribution of Agriculture"; "The New Distribution of Transport"; "The New Distribution of the Population." The last four of these titles indicate the scope of the respective chapters, whilst that entitled the "Discovery of New Nature" is mainly concerned with the result of recent geological and geographical exploration in the lesser-known portions of the Soviet territory. Great economic possibilities have already been disclosed in the course of this survey work, which has resulted in the discovery of coalfields and iron-ore deposits of hitherto unsuspected number and magnitude, whilst the Soviet petroleum resources have also been shown to be much larger than was previously supposed.

It is not possible to give an adequate account here of the great economic potentialities outlined in the volume, or the practical results which are recorded, but the book may be recommended to all readers interested in the development of the Soviet Union, who will find it an illuminating work and worth their perusal.

TROPICAL PLANTING AND GARDENING. By H. F. Macmillan. Pp. x + 560, $8\frac{3}{4} \times 5\frac{3}{4}$. Fourth Edition. (London: Macmillan & Co., Ltd., 1935.) Price 25*s.*

It is ten years since the previous edition of this well-known work was published (see this BULLETIN, 1925, **23**, 416). Mr. Macmillan has taken advantage of his retirement from the Ceylon Agricultural Service thoroughly to revise the book to meet a demand which arose much earlier than was anticipated. Not only has the matter been brought up to date and amplified, but the opportunity has been taken of effecting various amendments, and although the book now occupies fewer pages, it actually contains more material; the illustrations, too, which were a feature of the previous edition, have been increased.

The general arrangement of the book remains unaltered; it is conveniently divided into five sections. The principles underlying horticulture and the methods of cultivation practised in the tropics are first dealt with. Then follow descriptions of flowering and ornamental trees, shrubs, climbers, etc., suitable for various elevations and conditions. The third

part deals with tropical and sub-tropical fruits, vegetables, spices, condiments and herbs. An important field is covered in section four: beverage and food crops, drugs, medicinal plants, masticatories, poisonous plants, oils and fats, rubber, gutta, gums, resins, fibres, dyes and tans, and grasses are described, and useful information relating to the cultivation, propagation, harvesting, preparation, yield and varieties of the different products is also given. The final section is devoted to miscellaneous subjects such as perfumes, insecticide plants, pests and diseases and their methods of control, transport and packing of plants, seeds and bulbs, and storage of seeds, together with a glossary and a very full index of references. An additional chapter, included in Section II, "for arid and sub-desert regions: selection of trees, fruits, and vegetables," should prove to be of considerable practical value to those in areas where such conditions prevail.

Although originally prepared with special reference to Ceylon, the book covers so wide a field that it will undoubtedly continue to be used and appreciated by all connected with agriculture or horticulture in the tropics and sub-tropics. To those not already acquainted with the work it can be recommended with confidence.

GREEN HAVOC IN THE LANDS OF THE CARIBBEAN. By C. W. Wardlaw. Pp. 318, $8\frac{1}{2} \times 5\frac{1}{2}$. (Edinburgh and London: William Blackwood & Sons, Ltd., 1935.) Price 12*s.* 6*d.*

All interested in the banana growing industry will be familiar with Dr. Wardlaw's investigations of banana diseases, as contained in his recently published *Diseases of the Banana and the Manila Hemp Plant* (see this BULLETIN, 1935, **33**, 403). The present volume records in a pleasantly written manner his travels through the West Indies and Central and Southern America in search of first-hand information on the various ills to which the plant is subject, and his impressions of the countries and their peoples. He brings out in a striking way the devastating effect of the worst of the diseases, the Wilt or Panama disease, which in quite a short time put out of cultivation, on a conservative estimate, 15,000 acres in Jamaica, 50,000 acres in Panama, at least an equal area in Costa Rica, and thousands of acres in Guatemala, Honduras and elsewhere. The effect of this on the inhabitants may be imagined. How the problem of overcoming the disease is being tackled is dealt with in a chapter bearing the characteristic title, "Chiefly a Matter of Breeding."

In a chapter on Costa Rica, where bananas are grown "in the grand manner," Dr. Wardlaw describes how a plantation is established, from the time the agricultural explorer sets out

with a soil-auger, often through a jungle, waist deep in water, with snakes and alligators for company, in search of suitable land, to its completion with drainage canals, roads, bridges and tramways. And so he takes the reader with him through Guatemala, Jamaica, Colombia, Panama and along the Spanish Main on his way to Trinidad, thence to St. Lucia, Dutch Guiana and British Guiana, with finally a diversion to Sao Paulo in Brazil.

As the author points out in his Foreword, "he has duly restrained his exuberance in things botanical," and the book can be thoroughly recommended to the general reader as well as to those more closely connected with the production and distribution of the "Fruit of the Wise Men."

THE CHEMISTRY OF SYNTHETIC RESINS. By Carleton Ellis. Volume I, Pp. 1-829; Volume II, Pp. 830-1615, 9 × 6. (New York: Reinhold Publishing Company; London: Chapman & Hall, Ltd., 1935.) Price £4 17*s.* 6*d.*

The first edition of this book, a notice of which appeared in this BULLETIN (1923, **21**, 560), was published in one volume of just over 500 pages, under the title *Synthetic Resins and their Plastics.* The astonishing progress which has taken place in this field of chemical research has necessitated a complete revision and expansion of the book and has led the author to change the title to one compatible with the broader knowledge since acquired of the causes and nature of resinification. Many of the materials previously mentioned which were of little, if of any, industrial value have since attained wider application and in almost every known industry there is now a demand for these products.

Introductory chapters describe generally the progress made in the different types of artificial resins, the requirements aimed at and the nature of resin formation. Exhaustive information is then furnished concerning the individual types and varieties of artificial resins, which includes an historical sketch of early investigations, sources of raw materials, constitution of the resins, their properties, methods of commercial production and their uses and application. Several chapters are devoted to the more important industrial resins such as cumarone, phenol-aldehyde, urea and alkyd resins, but much information is also supplied regarding a large number of other resinous products, including amine-aldehyde resins, nitro resins, resin esters, resins from rubber and those containing sulphur, etc. There are also chapters dealing with analytical and physical methods of testing artificial resins, moulding compositions and requirements. One of the most valuable features of the work is the vast

number of references which have been given to the original literature. A useful list of trade names of artificial resins is appended and there are full name and subject indexes.

Within the limits of a short review it is not possible to convey an adequate impression of the fund of information collected in these volumes, which will prove indispensable to all interested in the subject of artificial resins.

A TEXT-BOOK ON FOREST MANAGEMENT. By M. R. K. Jerram, M.C. Pp. x + 156, $8\frac{1}{2} \times 5\frac{1}{2}$. (London: Chapman & Hall, Ltd., 1935.) Price 10*s.* 6*d.*

This work is intended as an introduction to the subject of forest management for the use of students and to this extent replaces the coresponding part of Schlich's *Manual of Forestry*, which is now out of print and in some respects out of date. It is divided into three parts. The first deals with the foundations of forest management, including preliminary matters relating to the regulation of the yield, relations between the growing stock, increment and yield, silvicultural systems and yield regulations in regular and irregular forests. Part II is concerned with the preparation and control of a working plan and Part III with forest finance.

The author explains in his Preface that the book "is not intended to displace the study of those authors who deal with these subjects individually at much greater length; but it does represent an endeavour to introduce the student to all the more important problems involved, to explain the elementary principles on which their solutions are based, and to provide a framework on which a fuller knowledge may be built up by lectures, reading and study of practice in the forest itself." Within these limits he has succeeded in producing a text-book which should be of great service to students of forestry in this country.

TERMITES AND TERMITE CONTROL. A Report to the Termite Investigations Committee. Editor-in-Chief, Charles A. Kofoid, Ph.D., Sc.D. Pp. xxvii + 795, $9\frac{1}{4} \times 6\frac{1}{4}$. Second Edition, Revised. (Berkeley: University of California Press; London: Cambridge University Press, 1934.) Price 22*s.* 6*d.*

The second edition of this important work has followed closely on the first, a lengthy notice of which appeared in this BULLETIN (1934, **32**, 503). The volume is described as "A discussion of the biology of termites and an account of the termites of the United States, Mexico, the Canal Zone, the West Indies, Hawaii and the Philippine Islands, with recommendations for prevention and control of termite damage by

methods of construction and the use of chemically treated and unpalatable woods."

It is explained in the Preface that the new edition contains substantial changes and additions owing to researches continued by the authors of the respective chapters, but the general arrangement and the bulk of the contents of the work remain unaltered. The comments offered in the earlier notice, therefore, do not require modification. The volume is highly technical and contains too large a mass of detail to permit of comprehensive treatment here; it must suffice to say that any reader interested in the scientific or practical aspects of termites and their control, who has not had occasion to peruse the first edition, will find in the present work a very full and authoritative presentation of the subject.

HISTORICAL GEOLOGY OF THE ANTILLEAN-CARIBBEAN REGION. By Charles Schuchert, D.Sc., LL.D. Pp. xxvi + 811, 9 × 6. (New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1935.) Price 50*s*.

This historical geology of the Antillean-Caribbean region treats of what is claimed by the author to be, geologically, one of the most interesting areas in the world. The author explains in his preface that for many years he has been preparing palæogeographical maps of North America; his scheme in this book has been to build an historical geology of North America around these palæogeographical maps. Apart from detailed studies resulting from the recent spread of petroleum exploration, most of the results have been obtained from reconnaissance work in semi-tropical and tropical climates; and the author admits that the geology of the Antillean-Caribbean region is known only in its broadest outlines.

The stratigraphy and palæontology of the Cainozoic rocks are usually better known than those of other rocks in the region. The Upper Cretaceous, although of wide extent, is less well dated than the Cainozoic, and the Lower Cretaceous is said to be poorly understood, except in the grand Mexican sequence. The older Mesozoic history is stated to be usually obscure except in Mexico, where a part of the Upper Triassic is known to occur, followed by a long development representing most of the Jurassic, the longest and best sequence of this period in North America. What there is of the Palæozoic record is everywhere obscured through folding and metamorphism, and the life of the era is almost wholly unknown.

An account of the historical geology of this vast area has rendered necessary a fairly bulky volume with nearly 800 pages of text, 107 figures, eighteen half-tone plates, 16 full page

palæogeographical maps of the Central American-Antillean region from Middle Pennsylvanian to upper Pliocene-Pleistocene time and an index of over 40 pages. The work is divided into four sections—Introduction and Summary (pp. 1-57), the Three Middle American Basins (pp. 58-78), Biogeography (pp. 79-113) and The Lands (pp. 114-767). This last section is subdivided into the various land regions, a number of chapters being allotted to each. Sixteen chapters are devoted to Mexico, though other important oil producers such as Venezuela, Colombia and Trinidad receive only one chapter each. An important feature of the book is the valuable bibliography appended to each section and region.

The section on biogeography should appeal to a large group of readers, especially with regard to the evidence of faunal migration and former land bridges. The book as a whole should prove to be of great value to those who, on account of their interests in petroleum, economic minerals, or general geology, require a handbook dealing with the geological history of the numerous territories of this great region, including such British possessions as Bermuda, Jamaica, the Bahamas, British Honduras, the Leeward and Windward Islands, and Trinidad.

THE BOOK OF MINERALS. By Alfred C. Hawkins. Pp. xii + 161, $7\frac{1}{2} \times 5$. (New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1935.) Price 7*s.* 6*d.*

This little book is intended chiefly for the "man in the street" who would like to learn something about minerals, which are often so important in our every-day life. It is, therefore, written in a simple, interesting and practical way, technical terms being kept as few as possible and fully explained when necessary.

There are five chapters in the book, the first two of which deal with general observations regarding minerals and explain what they are, how they crystallise, where they occur and how they were formed. The third chapter deals with the identification of minerals by means of the blowpipe and the microscope, and is followed by a useful chapter on the types of minerals one may expect to find in various quarries and mines. Chapter 5 consists of about 100 pages and gives a good elementary account of the more important mineral species.

The book is well written and illustrated, most of the illustrations being photographs of specimens in the mineral collection of the Natural History Museum of the Academy of Natural Science of Philadelphia.

TECHNICAL DATA ON FUEL. Edited by H. M. Spiers, M.A., B.Sc., F.I.C. Fourth Edition. Pp. xvi + 358, 7½ × 5. (London: The British National Committee, World Power Conference, 1935.) Price 12*s.* 6*d.*

The second and third editions of this compilation have both been reviewed in this BULLETIN (1930, **28**, 405, and 1932, **30**, 401). The present edition fully maintains the high standard of usefulness which has already been established, and shows a considerable growth in the volume of technical data included, the number of pages having increased from 302 in the last edition to 358, the number of tables from 210 to 256, and the number of diagrams from 57 to 66.

The Technical Data on Fuel Committee, under whose auspices the book is published, has also expanded since the date of the last edition, the number of its members having increased from thirteen to seventeen. The names and connections of those added show that there has been no falling off in the authoritative nature of the personnel and that the needs of all those interested in fuel and its applications, from a technical point of view, are likely to have been adequately considered.

The book contains a vast amount of information essential, not only to the fuel technician, but also to the chemist, chemical engineer and others, and is rapidly taking its place among those reference books the possession of which is almost essential to those who require reliable technical data of this type.

ELECTROLYTIC OXIDATION AND REDUCTION: INORGANIC AND ORGANIC. By S. Glasstone, D.Sc., Ph.D., F.I.C., and A. Hickling, M.Sc., Ph.D. Being Volume IX of a Series of Monographs on Applied Chemistry under the Editorship of E. Howard Tripp, Ph.D. Pp. ix + 420, 8½ × 5½. (London: Chapman and Hall, Ltd., 1935.) Price 25*s.*

In view of the great interest and importance at the present time of electrolytic processes, from the industrial as well as the purely scientific standpoint, the authors of this work considered the moment opportune for the publication of a treatise dealing with electro-chemical oxidation and reduction reactions from both theoretical and technical aspects. In the present volume they have dealt with reactions involving inorganic as well as organic compounds and have made a "serious attempt to elucidate, as far as possible, the underlying principles of the reactions described." They have not attempted to discuss experimental methods in detail, nor to describe manufacturing processes, their main aim being to indicate the basic theoretical significance of the observations

and to see how the optimum conditions for any process can be realised.

The book forms an excellent digest of the abundant literature on the subject. Of particular help will be the full list of references furnished at the end of each chapter; the list relating to the oxidation of fatty acids, for example, comprises 130 items. It should prove to be, as the authors hope, "of value both to research workers and to technical chemists interested in the enormous possibilities of electrolytic methods."

DAS O-OXYCHINOLIN "OXIN." By Dr. Richard Berg. Pp. vii + 94, 10 × 6½. (Stuttgart: Ferdinand Enke Verlag, 1935.) Price, bound, RM. 10·20; unbound, RM. 8·80.

Many organic reagents have been recently introduced into inorganic analysis, most of them being employed in colour or "spot" tests for small quantities of elements, though a few are used in gravimetric or volumetric analysis. The two outstanding examples of the latter class are cupferron and 8-oxyquinoline (abbreviated to "oxine"). The use of cupferron was suggested by Baudisch as long ago as 1909 and this reagent is now used in a number of separations which were performed with great difficulty by the older methods.

Berg, in 1927, published the first of a long series of papers dealing with the analytical reactions of "oxine." Other workers have since extended his results and so many uses have been suggested that a brief description by Dr. Berg of the applications of oxine in inorganic analysis fills this 94-page book, which is volume 34 of the series "Die chemische Analyse."

Quantitative methods for the separation and estimation of 25 elements have already been worked out, but the subject is by no means exhausted and is continually widening in scope. It might be expected that a substance so reactive would be of little use in analytical separations, but, fortunately, the oxine complexes of different elements are stable under different conditions of hydrogen-ion concentration and the elements precipitated can be broadly separated into three groups. As the members of these groups are mostly separated from each other by simple methods, this procedure is not so serious a disadvantage as would appear at first sight. Many of the separations carried out by means of oxine, such as aluminium from beryllium, which was formerly very difficult, zinc from magnesium, and magnesium from lithium, are great improvements on the older methods.

Where interfering elements are not present or have been previously separated, the direct estimation of a number of elements is possible, the oxine complexes obtained being dried

and weighed, or dissolved in hydrochloric acid and titrated with standard bromate-bromide solution. Owing to the high molecular weight of the complex, the gravimetric method is especially suitable for the determination of small quantities of an element. A number of technical applications of oxine have been suggested, including the determination of magnesia in Portland cement and of zinc and magnesium in light alloys.

It is fitting that Dr. Berg should describe the reactions, so many of which he himself introduced, and he is to be congratulated on account of the valuable contributions to analytical chemistry which are summarised in this book.

BOOKS RECEIVED FOR NOTICE

THE ECONOMIC DEVELOPMENT OF THE BRITISH OVERSEAS EMPIRE. By the late L. C. A. Knowles, M.A., LL.M., Litt.D., and C. M. Knowles, LL.B. Volume III: The Union of South Africa. Pp. vii+356, $8\frac{1}{2}\times5\frac{1}{2}$. (London: George Routledge & Sons, Ltd., 1936.) Price 10*s*. 6*d*.

EMPIRE DEVELOPMENT AND PROPOSALS FOR THE ESTABLISHMENT OF AN EMPIRE DEVELOPMENT BOARD. By Sir Robert Hadfield, Bt., Hon.D.Sc., D.Met., F.R.S., F.I.C., M.Inst.C.E. Pp. 78, $9\frac{3}{4}\times6\frac{1}{4}$. (London: Chapman & Hall, Ltd., 1935.) Price 2*s*. 6*d*.

KENYA: CONTRASTS AND PROBLEMS. By L. S. B. Leakey, M.A., Ph.D., F.S.A., F.R.A.I. Pp. xiii+189, $7\frac{1}{2}\times5$. (London: Methuen & Co., Ltd., 1936.) Price 7*s*. 6*d*.

UGANDA. By H. B. Thomas, O.B.E., and Robert Scott. Pp. xx+559, $8\frac{1}{2}\times5\frac{1}{2}$. (Oxford: The University Press; London: Humphrey Milford, 1935.) Price 15*s*.

TROPISCHE UND SUBTROPISCHE WELTWIRTSCHAFTSPFLANZEN, IHRE GESCHICHTE, KULTUR UND VOLKSWIRTSCHAFTLICHE BEDEUTUNG. By Prof. Dr. Andreas Sprecher von Bernegg. III Teil, 3 Band: Der Teestrauch und der Tee; Die Mate- oder Paraguay-teepflanze. Pp. xvi+432, $9\frac{1}{2}\times6\frac{1}{4}$. (Stuttgart: Verlag von Ferdinand Enke, 1936.) Price, paper cover, RM.31; bound, RM.33.

MILK: PRODUCTION AND CONTROL. By W. Clunie Harvey, M.D., D.P.H., M.R.San.I., and Harry Hill, M.R.San.I., A.M.I.S.E., M.S.I.A. Pp. viii+555, 8½×5½. (London: H. K. Lewis & Co., Ltd., 1936.) Price 21*s.*

THE CHEMISTRY OF MILK. By W. L. Davies, Ph.D., D.Sc., F.I.C. Pp. xii+522, 8½×5½. (London: Chapman & Hall, Ltd., 1936.) Price 25*s.*

CHEMISTRY AND TECHNOLOGY OF WINES AND LIQUORS. By Karl M. Herstein, F.A.I.C., and Thomas C. Gregory. Pp. xii+360, 9×6. (London: Chapman & Hall, Ltd., 1935.) Price 30*s.*

PERFUMES, COSMETICS AND SOAPS, with especial reference to Synthetics. By William A. Poucher, Ph.C. Volume I. Being a Dictionary of Raw Materials together with an Account of the Nomenclature of Synthetics. Pp. x+439, 8½×5½. Fourth Edition. (London: Chapman & Hall, Ltd., 1936.) Price 25*s.*

FOREST BIBLIOGRAPHY WITH THE INDEX NUMBER 634.9 F. An International Decimal Classification on the basis of Melvil Dewey's system. Adopted on the recommendation of the International Committee on Forest Bibliography, 1906-1933. Pp. vii+100, 9¾×7¼. (Oxford: Hall the Printer Ltd., 1936.) Price 6*s.*

THE PROPERTIES OF AN AFRICAN MAHOGANY (*Khaya anthotheca* C.DC.). Forest Products Research Records—No. 6. Pp. 4, 9½×6. (London: Department of Scientific and Industrial Research, 1936.) Price 6*d.*

THE PROPERTIES OF MANSONIA (*Mansonia altissima* A. Chev.). Forest Products Research Records—No. 7. Pp. 4, 9½×6. (London: Department of Scientific and Industrial Research, 1936.) Price 6*d.*

THE FINANCIAL POST SURVEY OF MINES. Tenth Annual Edition, 1935-36. Pp. 360, 11¾×8¾. (Toronto; Montreal; New York; London, England: The Maclean Publishing Company, Ltd., 1935.) Price $2.00.

METALLIFEROUS MINE SURVEYING. By Frederick Winiberg. Pp. ix+282, 8½×5½. Second Edition. (London: Mining Publications, Ltd., 1935.) Price 15*s.*

LES ROCHES SEDIMENTAIRES DE FRANCE. Roches Carbonatées (Calcaires et Dolomies). By Lucien Cayeux. Pp. 447, 12×9½. (Paris: Masson et Cie., 1935.) Price 200 *Fr.*

SULFURIC ACID MANUFACTURE. By Andrew M. Fairlie. (American Chemical Society Monograph Series.) Pp. 669, 9×6. (New York: Reinhold Publishing Corporation; London: Chapman & Hall, Ltd., 1936.) Price 48*s.* 6*d.*

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REPORTS OF RECENT INVESTIGATIONS AT THE IMPERIAL INSTITUTE

Selected from the Reports made to the Dominion, Indian and Colonial Governments

CHAULMOOGRA OILS

THE chaulmoogra oil employed in the treatment of leprosy is obtained from the seeds of various species of *Hydnocarpus*. Chief among these are *H. Wightiana* Blume, *H. anthelmintica* Pierre and *H. Kurzii* Warb. (= *Taraktogenos Kurzii* King). The last-named was formerly the chief source of the seeds used in India, whilst *H. anthelmintica* of Indo-China and Siam is stated to be the source of most of the seeds used in China. It is also understood that the oil of *H. anthelmintica* is being employed with satisfactory results in Siam (see this BULLETIN, 1931, 29, 68). It has been found, however, that the most effective oil is that derived from *H. Wightiana*, an Indian species and this oil is the only one recognised in the British Pharmacopœia (1932).

Hitherto the chaulmoogra oil employed in the leprosy campaign in Empire countries has been derived from India, but the cultivation of the different trees has in recent years been undertaken in many other tropical parts of the Empire, with a view to supplying the local needs. Progress reports on the experiments with various species in Ceylon, Malaya and Uganda have appeared from time to time in this BULLETIN in the section "Recent Research on Empire Products," whilst a report on a sample of *H. anthelmintica* seed from

Ceylon has also been published (1930, 28, 6). Reference may also be made to a report on the examination of the seeds of *H. Woodii* from North Borneo, the oil of which was shown to contain glycerides of hydnocarpic and chaulmoogric acids and in this respect to resemble that from the seeds of other species of *Hydnocarpus*.

During the last two or three years seeds of *H. Wightiana* from Nigeria, Ceylon and Malaya have been examined at the Imperial Institute and also a sample of *H. anthelmintica* seed from Malaya. The results of their investigation are given below.

In connection with the experiments being carried out with *H. Wightiana* in various Empire countries it may be mentioned that there appears to be no possibility of finding a market for the seeds in the United Kingdom, as they are not imported here for crushing. It is the usual commercial practice to import the oil itself, which is better prepared from the fresh seeds. If, after satisfying the local needs, there should be a surplus available for export, it is essential that the oil should reach the high standard maintained by the Indian producer if it is to find a ready market.

Hydnocarpus Wightiana Seed from Nigeria

The sample which is the subject of this report was forwarded to the Imperial Institute by the Senior Assistant Conservator of Forests, i/c Sylviculture, Sapoba, in June 1935.

The sample consisted of irregularly-shaped seeds, mostly dark brown externally. In general appearance they were similar to samples of *H. Wightiana* seeds previously examined at the Imperial Institute. They consisted of a thin woody shell (38 per cent.) enclosing a fairly hard, cream-coloured, oily kernel (62 per cent.).

The seeds varied in length from 0·6 to 1·0 in. and in width from 0·4 to 0·6 in. The average weight of 100 seeds was 118 grams and that of 100 kernels 73 grams.

The kernels were found to contain 4·3 per cent. of moisture and to yield on extraction with light petroleum 61·5 per cent. of oil, equivalent to a yield of 64·3 per cent. from the moisture-free kernels or 38·1 per cent. expressed on the entire seeds as received.

The British Pharmacopœia specifies that *Hydnocarpus*

Wightiana oil must be obtained by cold expression and in order to ascertain whether the present sample would yield a product conforming to the requirements of the Pharmacopœia a quantity of oil was prepared by cold-pressing the kernels in an oil press. The oil thus prepared was a fairly soft, cream-coloured fat. On examination it gave the following constants, which are shown in comparison with the requirements of the British Pharmacopœia (1932) for *Hydnocarpus Wightiana* oil :—

	Present sample (cold-pressed oil).	British Pharmacopœia requirements.
Specific gravity at 25°/25° C.	0·9548	0·950–0·960
Specific rotation in chloroform $[\alpha]_{D}^{20° C.}$	+55·4°	not less than +53°
Refractive index at 40° C.	1·4738	1·472–1·476
Melting point (British Pharmacopœia method)	24·2° C.	20°–25° C.
Acid value	1·2	not more than 25
Saponification value	202·2	198–204
Iodine value (Wijs, 30 mins.) *per cent.*	98·2	97–103

The foregoing results show that the present seeds contained a normal percentage of oil and that the cold-drawn oil fulfilled the requirements of the British Pharmacopœia in respect of the constants mentioned above. There is, however, a further Pharmacopœia requirement, viz. that *Hydnocarpus Wightiana* oil should be almost wholly soluble in hot 90 per cent. alcohol and the present oil did not exhibit this property, possibly owing to its unusually low free acidity. As indicated above, the British Pharmacopœia allows the oil to have an acid value as high as 25 and the effect of high acidity is to render the oil more soluble in hot alcohol. The non-compliance of the oil in this respect with the requirements of the Pharmacopœia is, however, not important.

Composition of the Oil

The composition of the oil was investigated with the following results.

The method adopted consisted (1) in preparing and fractionally distilling the ethyl esters of the oil and (2) in converting the fractions so obtained into the free fatty acids and further purifying them by fractional crystallisation.

The oil was extracted from the kernels with light petroleum and as previously mentioned was obtained as a fairly soft, cream-coloured fat. It possessed the characteristic odour

of Hydnocarpus oils. The melting point of the fat was low and at high room temperatures it melted to a light golden-yellow oil.

The fatty acids prepared from the oil gave the following constants :—

Specific rotation in chloroform $[\alpha]_D^{20^\circ C.}$ . .	$+55{\cdot}9^\circ$
Solidifying point	$35{\cdot}9^\circ$C.

Fractional Distillation of the Ethyl Esters

The ethyl esters were prepared from the oil by the method described by Perkins and Cruz (*Philipp. J. Sci.*, 1923, **23**, 557). After washing and drying over anhydrous sodium sulphate the esters were obtained as a yellow, mobile liquid, with a specific gravity of 0·9105 at 15·5° C./15·5° C.

A quantity of 350 cc. (approximately 319 grams) of the ethyl esters thus obtained was fractionally distilled under reduced pressure in a current of dry carbon dioxide, the pressure being maintained at 10 mm. by means of a vacuum pump and a pressure regulator. The esters were distilled from a Kon flask immersed in a bath of heat-circulating oil.

After the initial distillation the original flask was replaced by a smaller Kon flask fitted with a tap funnel. The first fraction was then re-distilled and successive fractions were run in as the temperature reached the bottom of the temperature range throughout which they had been collected. Owing to the small difference in the boiling points of ethyl hydnocarpate and ethyl chaulmoograte, repeated fractionation was necessary in order to ensure good separation. After five distillations the esters had been separated into the fractions shown in the following table, in which are also included the optical rotations determined for each fraction :—

Fraction.	Temperature range over which fraction was collected.	Percentage by weight of total esters.	Optical rotation at 23°–24° C.
A	174°–184° C.	3·5	+44·0°
B	184°–189° C.	3·3	+45·5°
C	189°–191° C.	20·8	+47·7°
D	191°–193° C.	18·7	+48·2°
E	193°–197° C.	14·5	+46·9°
F	201°–203° C.	7·4	+44·8°
G	205°–208° C.	10·6	+44·1°
H	208°–209·5° C.	10·9	+44·1°
I	(non-distillable residue)	5·0	—

The experimental loss in the five distillations was 5·3 per cent.

It will be observed that not only was every fraction highly optically active, but that there was only a comparatively small variation in the rotations of the different fractions. This is an indication that the original total esters consisted wholly, or almost wholly, of ethyl hydnocarpate and ethyl chaulmoograte, which have very similar optical rotations. There was no evidence of the presence of palmitic acid or any other straight-chain fatty acid in the oil. If palmitic acid, which has been found in the oils of *Hydnocarpus* (*Taraktogenos*) *Kurzii* and *Oncoba echinata* seeds, had been present, its ethyl ester would have distilled in the lower-boiling fractions and the fractions in which it occurred would have been of diminished optical activity.

Crystallisation of the Fatty Acids

Each fraction was saponified in the usual way and the fatty acids liberated by the addition of a mineral acid. After washing thoroughly, the acids were crystallised from 80 per cent. alcohol. The crystals were filtered off and the filtrate evaporated to give a second crop of crystals. The acids remaining in the mother-liquors were recovered by boiling off the solvent. The following table gives the melting points of the acids crystallised out from each fraction. The melting points of the residues recovered from the mother-liquors were determined by the open tube method used for fats, as these acids were fatty rather than crystalline in nature.

Fraction.	Melting point of first crop.	Melting point of second crop.	Melting point of residue in mother-liquors.
A	57°–58° C.	47°–49° C.	31° C.
B	57°–58° C.	48°–49° C.	(negligible residue)
C	57°–58° C.	47° C.	28°–29° C.
D	53° C.	49°–50° C.	39° C.
E	51° C.	—	40° C.
F	61° C.	55°–56° C.	32° C.
G	66° C.	63°–64° C.	28°–29° C.
H	67° C.	61°–62° C.	(liquid)

The melting point of the fatty acids indicated that fractions A, B, C and possibly D consisted largely of hydnocarpic acid (melting point 59° to 60° C.). Fraction E appeared to be an intermediate fraction containing a mixture of both acids

and F, G and H were probably chaulmoogric acid (melting point 68° C.) together with a small amount of a liquid acid.

The fractions were submitted to further fractional crystallisation. Crops of crystals having the same melting point and an unchanged mixed melting point were added together. Finally, from fractions A, B, C and D there was obtained 81 grams of hydnocarpic acid, which, after a final recrystallisation from light petroleum, was characterised as follows:—

	Present figures.	Figures for comparison.
Melting point	59°–60° C.	59°–60° C.[1]
Specific rotation in chloroform $[\alpha]_D^{20° C.}$	+67·8°	+68·1° (temp. not stated)[1]
Iodine value (Wijs, 30 mins.) *per cent.*	100·6	100·6[2]
Percentage of silver in silver salt . .	29·8	30·0[2]

[1] *Power and Barrowcliff, J. Chem. Soc.*, 1905, **87**, 884.
[2] *Theoretical figures.*

A quantity of 37·5 grams of chaulmoogric acid was crystallised from fractions F, G and H, recrystallised from light petroleum and identified as follows:—

	Present figures.	Figures for comparison.
Melting point.	68·5° C.	68° C.[1]
Specific rotation in chloroform $[\alpha]_D^{20° C.}$.	+57·6°	+56°[1]
Iodine value (Wijs, 30 mins.) *per cent.*	89·1	90·6[2]
Percentage of silver in silver salt . .	27·9	27·9[2]

[1] *Power and Gornall, J. Chem. Soc.*, 1904, **85**, 838.
[2] *Theoretical figures.*

The fatty acids left in the mother-liquors of the last three fractions had the following melting points: F, 32° C.; G, 28° to 29° C.; H, liquid at room temperature. It is, therefore, evident that the higher fractions contained, in addition to chaulmoogric acid, a liquid fatty acid. The occurrence of a liquid fatty acid associated with chaulmoogric acid in the higher-boiling ester fractions has previously been reported. Wrenshall and Dean (*Publ. Hlth. Bull., Wash.*, 1924, **141**, 12) found a highly unsaturated, optically active, liquid acid in chaulmoogra oil and André and Jouatte (*Bull. Soc. Chim.*, 1928 (IV), **43**, 347) isolated what appeared to be the same substance, which they named "gorlic" acid, from Gorli seeds, *Oncoba echinata* Oliver. The structure of this substance has not yet been definitely established, but there

is evidence for believing it to be chaulmoogric acid with a second double bond in the straight-chain part of the molecule.

Approximately 8 grams of liquid acid were isolated from the present sample of *H. Wightiana* oil. It was pale yellow in colour, strongly reducing to alkaline permanganate solution and its specific rotation in chloroform was +44·6° at 20° C. André and Jouatte give a specific rotation of +50° 18′ for the purest gorlic acid they obtained.

Conclusions

The presence of both hydnocarpic and chaulmoogric acids in the present *Hydnocarpus Wightiana* oil has been established and apart from a small amount of an optically active liquid acid, possibly gorlic acid, no acids other than hydnocarpic and chaulmoogric could be isolated. The oil is richer in hydnocarpic than chaulmoogric acid. This result is in agreement with the work of Georgi, Buckley and Teik on the esters of the oil of *H. Wightiana* Blume from Malaya.

The cold-drawn oil was of good quality and conformed with the requirements of the British Pharmacopœia except on a point of minor importance.

Hydnocarpus Wightiana Seed from Ceylon

A sample of *H. Wightiana* seed was forwarded to the Imperial Institute by a private firm in May 1933. It consisted of seed of normal appearance. The size varied rather widely, the smallest being ½ in. long and ¼ in. broad and the largest 1¼ in. long and ¾ in. broad.

The seeds were found to consist of shell, 29·5 per cent. and kernel, 70·5 per cent. The average weight of the seeds was 1·35 grams and of the kernels 0·95 gram.

The kernels were examined with the following results :—

	Per cent.
Moisture	5·5
Oil, in kernels as received . . .	62·3
Oil, calculated on moisture-free kernels .	65·9
Oil, calculated on entire seed as received .	43·9

The oil, as extracted from the kernels by cold pressing, was found to have the following constants, which are shown in comparison with the requirements of the British Pharmacopœia (1932) for medicinal *H. Wightiana* oil :—

	Present sample.	British Pharmacopœia requirements.
Specific gravity at 25°/25° C.	0·9557	0·950–0·960
Specific rotation in chloroform $[\alpha]_D^{20° C.}$	+59·8°	not less than +53°
Refractive index at 40° C.	1·4740	1·472–1·476
Melting point (by the B.P. method)	24·5° C.	20°–25 ° C.
Acid value	1·4	not more than 25
Saponification value	201·1	198–204
Iodine value (Wijs, 30 mins.) *per cent.*	99·1	97–103

These results show that the oil from the Ceylon seed complies with the requirements of the British Pharmacopœia.

Hydnocarpus Wightiana Seeds from Malaya

A sample of *H. Wightiana* seed, received from the Director of Agriculture, was forwarded to the Imperial Institute by the Agent, Malayan Information Agency, in January 1933.

The sample consisted of greyish-brown seeds, of the usual appearance and character of *H. Wightiana* seed.

The seeds were found to have the following composition, which is given in comparison with that of a sample examined in Malaya and with other recorded figures for *H. Wightiana* seeds :—

Seeds.		Present Sample.	Malay sample.[1]	Other recorded figures.[2]
Average weight	*grams*	1·55	1·40	—
Shell	*per cent.*	32·3	32·0	25
Kernel	*per cent.*	67·7	68·0	75
Kernels.				
Average weight	*grams*	1·05	0·95	—
Moisture	*per cent.*	5·5	6·6	—
Oil in kernels as received (light petroleum extract)	*per cent.*	64·3	61·2	54·9
Oil expressed on moisture-free kernels	*per cent.*	68·0	65·2	—
Oil expressed on whole seeds as received	*per cent.*	43·5	41·6	41·2

[1] *Malayan Department of Agriculture, Scientific Series, No.* 9, 1932, *p.* 11.
[2] *Power and Barrowcliff, J. Chem. Soc.*, 1905, **87**, 886.

The oil for detailed examination was obtained from the kernels by means of a laboratory oil press, the kernels being first roughly cut up by means of a mincing machine and then warmed to a temperature of about 30° C. The constants of the oil so obtained are given below, in comparison with the

British Pharmacopœia (1932) requirements for Hydnocarpus oil, the constants obtained for this oil in Malaya and other recorded figures :—

	Present sample.	British Pharmacopœia (1932) requirements.	Malay sample.[1]	Other recorded figures.
Specific gravity at 25°/25° C.	0·9573	0·950 to 0·960	0·9534 [2]	0·947 to 0·958
Optical rotation in chloroform $[\alpha]_D$	+58° at 20° C.	Not less than +53°	+58·5° at 28° C.	+51° to +57·7°
Refractive index at 40° C.	1·4745	1·472 to 1·476	1·4770 at 27° C.	1·4763 to 1·4772
Melting point (British Pharmacopœia method)	22·2° C.	20° to 25° C.	—	22° to 23° C.
Acid value	0·3	Not more than 25	0·1	3·8
Saponification value	205·1	198 to 204	202·1	200 to 208
Iodine value . *per cent.*	98·9	97 to 103	99·9	93 to 101·3

[1] *Malayan Department of Agriculture, Scientific Series, No.* 9, 1932, *p.* 12.
[2] *At* 30°/15° C.

This sample of *Hydnocarpus Wightiana* seeds contained a high percentage of oil, which conformed to the requirements of the British Pharmacopœia, except in regard to the saponification value, which was slightly high.

Hydnocarpus anthelmintica Seeds from Malaya

The sample of *H. anthelmintica* seed which is the subject of this report had also been received from the Director of Agriculture and was forwarded to the Imperial Institute by the Agent, Malayan Information Agency, in January 1933.

The sample consisted of irregularly-shaped seeds of the usual appearance and character of *H. anthelmintica* seeds.

The seeds were found to have the following composition, which is given in comparison with those of a sample of *H. anthelmintica* seeds from Ceylon previously examined at the Imperial Institute (this Bulletin, 1930, **28**, 6) and of two samples examined in Malaya and with other recorded figures for the seeds :—

Seeds.	Present sample.	Ceylon sample.	Malayan samples.[1] (1)	(2)	Other recorded figures.
Average weight *grams*	2·0	2·0	1·86	2·42	—
Shell . . *per cent.*	66·7	70·0	65·7	68·2	68·8 [2]
Kernel . . *per cent.*	33·3	30·0	34·3	31·8	31·2 [2]
Kernels.					
Average weight *grams*	0·67	0·6	0·64	0·77	—
Moisture . *per cent.*	6·1	7·3	10·1	26·5	—
Oil in kernels as received (light petroleum extract) . *per cent.*	59·2	60·1	53·7	42·5	56·4 [2]
Oil expressed on moisture-free kernels *per cent.*	63·0	64·8	59·7	57·8	—
Oil expressed on whole seed as received *per cent.*	19·7	18·0	18·4	13·5	12 to 18

[1] *Malayan Department of Agriculture, Scientific Series*, No. 9, 1932, *p.* 2.
[2] *Power and Barrowcliff, J. Chem. Soc.*, 1905, **87**, 893.

The seeds were in good clean condition and the yield of oil compares favourably with recorded figures for *H. anthelmintica* seeds. Although the oil of this species might be used locally, it is not, as already indicated, recognised in the British Pharmacopœia (1932) and there is apparently no market for either the seeds or the oil in the United Kingdom.

ARTICLES

SCIENTIFIC ASPECTS OF CACAO FERMENTATION[1]

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PART V

ENZYMES, TANNINS, AND THEOBROMINE

THE ENZYMES PRESENT

WHEN the bean dies the enzymes are liberated and certain important reactions in the interior result from this. Many of the reactions of normal metabolism are reversible balanced actions ; after death, they are no longer balanced, but proceed for the most part in the direction of hydrolysis and the breaking down of complex substances. Two investigators, Brill [61] and Ciferri [15] have made careful tests for the presence of a large number of enzymes in Forastero cacao. Unfortunately, their results present almost as many disagreements as agreements. It is possible that the ripeness of the cacao or the nearness to germination caused the variations, but Ciferri suggests that they may be due to different conditions

[1] Parts I-IV of this article were published in this BULLETIN (1935, **33**, 31, 147, 306, 453).

in the tests themselves. Their results have been tabulated here under two headings, namely, the enzymes in the fresh material and the enzymes found after (1) drying or (2) fermentation and drying had taken place. This enables comparisons to be made between the results obtained by the two investigators and between the fresh bean and the treated. Of the beans which received treatment, those which were simply dried correspond to the unfermented beans found in commercial cacaos, whilst the beans described as fermented by both Brill and Ciferri could more fairly be called half-fermented since they were only kept four days at ordinary tropical temperatures.

The fresh beans contain the greatest number of enzymes, the dried unfermented beans somewhat less and the dried fermented beans are, according to Ciferri, almost totally lacking in enzyme activity.

ENZYMES IN THE FRESH PULP AND SEED
(FORASTERO CACAO)

	Pulp.	Cotyledons, etc.		Whole Bean
	Fresh Pulp.	Fresh Seed without Pulp.		Fresh Pulp and Seed.
Investigator	Brill.	Brill.	Ciferri.	Ciferri.
Cacao	Philippine Cacao.		Dominican Cacao (Sanchez type.)	
A. HYDROLYSING ENZYMES.				
(a) *Decomposing carbohydrates*—				
Invertase (sucrase) . .	PP	O	P	P
Maltase	O	O	P	P
Raffinase	PPP	P	—	—
Amylase (diastase) . .	O	O	P	P
Dextrinase	O	O	O	P
(b) *Decomposing glucosides*—				
Emulsin	O	P	P	P
(c) *Converting proteins*—				
Protease (tryptophane test) .	P	O	—	—
Trypsin	O	O	O	O
(d) *Decomposing Fats*—				
Lipase	O	O	O	O
(e) *Decomposing organic compounds of phosphorus*—				
Glycerophosphatase . .	—	—	P	P
Phytase	—	—	P	P
B. OXIDISING AND REDUCING ENZYMES.				
Oxidases	PP	PPP	P	P
Peroxidases . . .	—	—	P	P
Catalase	—	—	P	P
Philothion	—	—	P	P
Reductase	PP	PPP	O	P

P=Present; PP=Present in quantity; PPP=Large quantity; O=Absent; a dash (—) indicates presence not tested for.

ENZYMES IN THE DRIED OR FERMENTED BEAN
(FORASTERO CACAO)

Preparation . . .	Beans simply washed and dried	Pulp-covered beans kept 4 days at 20-30° C. Pulp removed. Dried.	Pulp-covered beans kept 4 days at 20-30° C. Then pulp and skin removed.
Suggested description .	*Unfermented beans* (similar to commercial).	*Kernels of partly fermented beans.*	*Kernels of partly fermented beans.*
Investigator . . .	Ciferri.	Ciferri.	Brill.
Cacao	Dominican.	Dominican.	Philippine.
A. HYDROLYSING ENZYMES.			
(a) *Decomposing carbohydrates*—			
Invertase (sucrase)	P	O	P
Maltase . .	O	O	O
Raffinase . .	—	—	PP
Amylase (diastase)	P	O	PPP
Dextrinase . .	O	O	—
(b) *Decomposing glucosides*—			
Emulsin . .	?	O	O
(c) *Converting proteins*—			
Protease (tryptophane test) .	O	O	P
Trypsin . .	O	O	—
(d) *Decomposing fats*—			
Lipase . .	P	O	O
(e) *Decomposing organic compounds of phosphorus*—			
Glycerophosphatase	O	O	—
Phytase . .	O	O	—
B. OXIDISING AND REDUCING ENZYMES.			
Oxidases . .	P	P	P
Peroxidases .	P	P (?)	—
Catalase . .	P	?	—
Philothion . .	P	O	—
Reductase . .	O	O	PPP

In addition to the enzymes listed in the tables, the following were tested for but not found: lactase, trehalase, melibiase, inulase, pectinase, cellulase, protease, peptase (indole test), and albuminase (tryptophane test).

The most important enzymes in cacao are the oxidases. Before discussing these, brief comments on the action of the others will be made.

A.—Hydrolysing enzymes

Brill's finding of *raffinase* in the pulp and kernels raises the question of the nature of the sugars present. Many years ago Maurenbrecher and Tollens [57] examined the shells

and found, besides dextrose, l-arabinose, and d-galactose. The sugars found, however, are generally returned simply as sucrose and reducing sugars.

According to Harrison [42], whilst he found mere traces of sucrose in the fresh Calabacillo kernels, in fresh Forastero kernels he found 0·9 per cent. (or on the dry kernel, 1·4 per cent.). In both varieties the sucrose completely disappeared after fermentation. His figures for reducing sugars expressed to one place of decimals, are given below :—

Per cent. Glucose in Kernels

Kind of cacao.	*Fresh and wet.*	*Simply dried.*	*Fermented and dried.*
Calabacillo . .	1·0	1·5	1·0
Forastero . .	0·2	0·3	0·6

In the case of Forastero there is an increase on fermentation, though whether this is due to absorption from the pulp or hydrolysis of cane sugar in the cotyledon is not clear. Conceivably the glucose is produced by hydrolysis of a tannin glucoside.

In the kernel of the fermented Forastero cacao beans of commerce the sucrose is negligible. In certain types of unfermented cacaos which are sold, e.g. Arriba, up to 1 per cent. of sucrose may be present in the kernels, but the author has never found sucrose in fully fermented cacaos either in the nib or shell. The total reducing substances estimated by Fehling solution and calculated as glucose vary in different kinds of kernels from 0·1 to 2·0 per cent., but the evidence as to the part played by fermentation in this variation is inconclusive.[1] The reducing sugar in the shell, however, is appreciably less after fermentation and is often an indication of the degree of fermentation. Thus Harrison found 4 to 5 per cent. in the dry unfermented shell and less than 1 per cent. in the fermented shell.

Briefly, then, during fermentation any sucrose in the cotyledons or shell is inverted, and the reducing sugars in the shell are appreciably diminished.

The coagulating enzyme, *pectase*, is not mentioned. *Pectinase*, which converts pectic compounds into arabinose, was not found and the explanation of the breaking down of the pulp is incomplete. The coagulation of the viscous colloids into pasty flocs, which takes place in the pulp in the later stages of fermentation may be due to the changed acidity

[1] Jensen's statements (in his book *The Chemistry, Flavouring and Manufacture of Chocolate-Confectionery and Cocoa*) re *Caracas*: "The bean has a high sugar content (4·2 per cent.)—the average total sugars being only 2·6 per cent.", and *Arriba*: "The nib has a low starch and a high sugar (6·8 per cent.) content," require confirmation.

or simply to the precipitation of the pectin by oxidised tannins. The fermented cotyledons contain more pectin and mucilage than the unfermented.

Both investigators found *emulsin* in the fresh cotyledons, thus corroborating the work of Sack [52] on Surinam cacao. The emulsin is destroyed during fermentation. Sack's explanation that the beans turn brown owing to the splitting of a glucoside is not now generally accepted and the function of the emulsin remains obscure.

The findings for *diastase* are contradictory. According to Brill it is actually produced in the interior of the bean during fermentation and it is not accompanied by maltase. According to Ciferri diastase (accompanied by maltase) is present in the fresh bean but appears to be destroyed by fermentation. The cacao cotyledons contain starch and the presence of diastase might help to explain the development of the gummy juice which is mentioned above as being produced within the bean after several days' fermentation. Although Harrison [42] found a reduction in starch in both skins and kernels during fermentation, we now know [58] that the skins contain no true starch, and in the author's opinion, founded on estimations by the taká-diastase process, the destruction of starch in the cotyledons during fermentation is unproven. Diastase is present in a variety of seeds so that it is not surprising that Ciferri finds it in the fresh bean. It is possible that as fermentation proceeds the tannin present inhibits the action of the diastase.

Whilst the presence of any enzymes hydrolysing protein substances appears doubtful, the amount of protein nitrogen in the bean decreases during fermentation.

One naturally expects to find *lipase* in a seed so rich in fat as the cacao bean. It has been found by Ciferri alone, and only in the dried unfermented beans. As the cacao butter pressed from the beans has remarkably good keeping properties, the presence of lipase should be accepted with reserve. It may be, as Ciferri suggests, that the presence of the phosphatides (lecithin, etc.) in the cotyledons has interfered with the test. All kinds of cacao beans contain lecithin, generally 0·3 to 0·4 per cent., apparently combined (with the albumen) since none of it is soluble in ether [59]. There is some indication that the amount is decreased by fermentation.

In considering the effects of the enzymes, the following rough figures as usually given for the optimum and destruction temperatures are of interest. The effect of *p*H, saline content, etc., is ignored.

ENZYME REACTION TEMPERATURES

	Action.	*Optimum Temperature*	*Destruction Temperature.*
Invertase (sucrase)	Cane sugar to glucose and fructose . . .	52° C.	75° C
Raffinase . .	Raffinose to d-fructose and melibiose . . .	30° C.	75° C
Amylase (diastase)	Starch to dextrin and maltose, and eventually to glucose .	55° C.	75°-80° C
Protease . .	Proteins to albumoses and peptones	40° C.	70° C
Zymase . .	Sugars to alcohol and carbon dioxide	29° C.	40°-50° C.

It will be seen that the most favourable temperatures for invertase and amylase are a little above the usual highest temperatures of cacao fermentation. On the other hand, the best temperatures for raffinase and zymase are relatively low. If the temperature of destruction usually given applies to the zymase in tropical yeasts, then the production of alcohol must be brought almost to a standstill in the later stages of fermentation. Save for zymase, the enzymes given above should survive the temperature produced during sun drying, as this rarely exceeds 70° C. Invertase, raffinase and zymase (all derived from yeast) and amylase show optimum activity in an acid medium (*p*H=4·2 to 5·5). This is roughly the acidity of the pulp during the first four days of fermentation.

A consideration of the disagreement we have noted and of the fact that the fermented cacao bean is in the biological sense dead and in the biochemical sense dead as far as hydrolysing enzymes are concerned, leads to the conclusion that only the oxidising enzymes are of practical importance. If it should ever be shown that another enzyme is concerned in the development of the aroma (or the precursor of the substance which gives the aroma on roasting) this would be important also.

B.—Oxidising Enzymes

It will be noted that both investigators agree that the oxidase is present in the pulp, in the fresh cotyledons and in the fermented beans. Ciferri also found peroxidase in all these (thus corroborating Loew [16] in regard to the seeds). By the time the beans reach England the author can no longer find oxidase. Presumably this is due, as Falk observed in

the case of dried vegetables, to the fact that desiccation decreases oxidase activity. On the other hand, peroxidase survives and has been found by the author in unfermented beans from Accra and Trinidad.

Oxidases in general act at ordinary atmospheric temperatures. Bourquelot found they were most active at 42-45° C., above which their activity fell but rose again at 60-70° C. Schulte-im-Hofe [62] showed that the oxidase in cacao induced a more rapid oxidation at 50-60° C. than at 30-40° C. Both Fickendey [40] and Loew have proved that the oxidase is destroyed at 75° C. (167° F.).

Destructive effect of heat on the oxidase in cacao.

Temperature.	*Period.*	*Result.*	*Authority.*
60° C.	long periods.	not destroyed.	Stevens.
70° C.	1 hour.	not destroyed.	Fickendey.
75° C.		destroyed.	Fickendey.
75° C.		destroyed.	Loew.
80° C.	4 minutes.	destroyed.	Stevens.

It is important to note that temperatures which occur during fermentation and drying are sufficient to kill the bean and allow the full action of the oxidase. This is also true of the peroxidase, which Loew found withstood 75° C.

Oxidases act best in neutral or alkaline media (*p*H 7-10). They are inhibited by *p*H 2-3. As the valuable action of oxidase is slowed down by acidity, it has been suggested that acidity should be avoided in fermentation as far as possible, but we have seen that with fermentation the effective acidity of the pulp decreases and that the cotyledons do not become markedly acid, the hydrogen ion concentration not generally increasing beyond *p*H 5.

The cacao oxidase is soluble in water but may be brought down, by the oxidised tannins, in an insoluble form. In order that the oxidase may act it is essential for the bean to contain moisture; with 20 per cent. of water present, the action readily takes place; with 10 per cent. its action is greatly reduced but not entirely prevented.

It will be evident from the above that the cacao oxidase can act as soon as it is released during fermentation and can continue to act in natural sun-drying until the bean is almost dry.

The analyses given below were made under my direction

by A. Churchman. They illustrate the differences in composition which occur in commercial cacao as a result of fermentation.

THE CACAO BEAN OF COMMERCE

Analyses of Fermented and Unfermented West African Beans

	Unfermented and dried.	*Fermented and dried.*
Average weight of beans	1·072 grms.	1·020 grms.
Nib (Cotyledons)	89·60%	88·56%
Shell	9·63%	10·74%
Germ	·77%	·70%

	Unfermented Cotyledons.		Fermented Cotyledons.	
	% on original.	% on dry fat-free material.	% on original.	% on dry fat-free material.
Water	3·65	—	2·13	—
Fat	53·05	—	54·68	—
Ash.				
Total	2·63	6·07	2·74	6·34
Water Soluble	1·02	2·36	1·25	2·89
Water Insoluble	1·61	3·72	1·49	3·45
Sand, etc.	·05	·12	·05	·11
Alkalinity as K_2O	·51	1·18	·41	·95
Chlorides	·012	·028	·014	·032
Iron (Fe_2O_3)	·004	·009	·007	·016
Phosphoric Acid (P_2O_5)	·96	2·22	·60	1·39
Copper	·0024	·0055	·0028	·0065
Nitrogen.				
Total Nitrogen	2·28	5·27	2·16	5·00
Protein Nitrogen	1·50	3·46	1·34	3·10
Ammonia Nitrogen	·028	·065	·042	·097
Amide Nitrogen	·188	·434	·336	·778
Theobromine	1·71	3·95	1·42	3·29
Caffeine	·085	·196	·066	·152
Carbohydrates.				
Glucose	·30	·69	·10	·23
Sucrose	Nil	Nil	Nil	Nil
Starch (Taká Diastase Method)	6·10	14·09	6·14	14·22
Pectins	2·25	5·20	4·11	9·52
Fibre	2·09	4·83	2·13	4·93
Cellulose	1·92	4·43	1·90	4·39
Pentosans	1·27	2·93	1·21	2·80
Mucilage and Gums	·38	·88	1·84	4·26
Tannins.				
Tannic Acids (Lowenthal's method)	2·24	5·17	1·99	4·61
Cacao-Red	5·30	12·26	4·16	9·63
Acids.				
Acetic (free)	·014	·032	·136	·315
Oxalic	·29	·67	·30	·70
Extracts.				
Cold Water	15·28	35·28	12·29	28·46
Alcohol (85 per cent.)	16·80	38·80	9·67	22·39

The Cacao Tannins

Comparatively little is known about the tannins in cacao, but certain changes in colour and flavour which occur during fermentation and drying are due to alteration in the tannins and are of sufficient importance to warrant full discussion. In Criollo beans the cotyledons change from white to light brown and in Forastero from purple to dark brown or brownish-purple. If the unfermented white Criollo bean is rapidly dried it remains nearly white. If the unfermented purple Forastero bean is rapidly dried it appears, as explained above, slate in colour.

The change in colour of the bean can be produced in other ways than by fermentation. For example, if a bean is taken straight from the pod and cut in two, the surface exposed to the air begins to turn brown. The change in colour, however, does not readily occur throughout the bean unless it has been first killed by exposure to high temperature, freezing or chemical agents. The development of the brown colour, a change with which we are familiar in freshly-cut apples and other fruits, naturally suggests the presence of an oxidase system; oxygenase, peroxidase and a substance containing the ortho-dihydroxy grouping of catechol.

Fickendey has shown that carbon dioxide is produced when cacao beans are oxidised. This is in agreement with Bertrand's statement [63] that the oxidation of tannin in presence of an oxidase is attended by liberation of carbon dioxide. It is interesting to compare two of Bertrand's results with that of Fickendey :—

	Oxygen absorbed.	*Carbon Dioxide disengaged.*
Bertrand (1)	23·3 ccs.	13·7 ccs.
(2)	29·8 ccs.	16·4 ccs.
Fickendey (using cacao beans) .	9·0 ccs.	4·5 ccs.

It is a commonplace that many fruits as they mature and ripen become less astringent, but that there is any actual destruction of tannin is doubtful. The change in taste is probably caused by the tannin passing into an insoluble form or to its being less in evidence owing to reduction of acidity or increase in sugars. According to F. E. Lloyd [64] the tannin in *seeds* disappears as they mature. The author questioned if this were true of cacao, and conducted experiments

along the lines of Fickendey's mentioned above on fresh Accra beans. He found that ripe and unripe cotyledons acted in a similar manner when exposed to the oxygen of the air. There was no evidence that on ripening the tannins had decreased.

We have long known that certain properties of the cacao bean show that they contain substances resembling tannins, i.e. substances which have the ability to tan leather. What is more important to cocoa and chocolate manufacturers is that these substances partly dissolve in saliva and give the bean an austere, rough, dry, astringent binding taste. Tannins make the surface of the tongue firmer, less smooth and slightly cockled, so that it no longer slides so easily across the roof of the mouth. This astringency should not be confused with the bitter taste due to the theobromine. Some scientists appear to have assumed that as fermentation reduces the astringency due to tannins the ideal process would completely remove all astringency. This is an error: the tannins are as much a part of the characteristic taste of cocoa and chocolate as they are of tea, coffee or cider. It is only their crude excess in relation to the rest of the flavour that is objectionable and the amount that is ideal depends on the palate that judges it.

Most gallotannins yield glucose on hydrolysis. As mentioned above, under enzymes, the hydrolysis of a water extract of fermented cacao with acid does not increase the reducing sugars, so that no hydrolysable tannin yielding glucose is present. Whymper [44] was unable to find pyrogallol tannins in the fresh beans, or gallic acid in the final product.

Cacao Catechin

Several early workers investigated the tannin products in cacao beans, but it was Ultée and Van Dorssen [65] who in 1909 first definitely proved the presence of a catechin-like substance and a caffeine compound of this substance, which is found in fresh cacao beans in which the enzymes have been killed by immersing in boiling water. Ultée and Van Dorssen isolated it from Java cacao and called it "cacao-ol." Later Adam, Hardy and Nierenstein [66] proved that the purified catechin-like substance found by Ultée and Van Dorssen in Java cacao (Criollo) as well as similar substances obtained

by themselves from Trinidad cacao (Forastero-Criollo hybrids) and from West African cacao (Forastero) were the same, and that this catechin-like substance was actually catechin itself ($C_{15}H_{14}O_6$). It has been found also in cacao from Guayaquil, Costa Rica and Bahia.

Cacao catechin is identical with one of the catechins present in the cutch-producing acacias and has been identified by Nierenstein as l-acacatechin. Those interested in the structure of the catechins should note that the dispute between Nierenstein and Freudenberg on this subject continues. Freudenberg, Cox and Braun [67] agree that this catechin-like substance exists in the cacao bean. Indeed, they separated it from cacao from Trinidad, Porto Rico and Sumatra and also from Ultée's caffeine cacao-ol, but they do not agree that it has been correctly named by Nierenstein. Instead of being l-acacatechin, they state it is a stereoisomer of catechin, namely, l-epicatechin.

Separation of Catechin and Tannin

W. B. Adam has made a valuable contribution on the separation and estimation of these substances. His method [68] was to drop the fresh unfermented Accra cacao bean into boiling water to destroy the enzymes and then extract the cotyledons with solvents in the following order: (1) petroleum ether, two days, (2) chloroform, five days, (3) ether, at least six days, and (4) ethyl acetate. Petroleum ether removes cacao butter. Chloroform removes the theobromine and caffeine and, incidentally, splits up the cacao catechin caffeine which is present. The catechin (and resin) is now extracted with ether. From the residue, by extraction with ethyl acetate, Adam obtained cacao catechu-tannin (and red products, probably phlobaphenes).

It may be well to set out briefly the properties of the substances mentioned above.

Cacao catechin.—Colourless prisms which slowly loose their water of crystallisation, $4H_2O$. The anhydrous needles melt at 229° C. Insoluble in petroleum ether and chloroform; soluble in water, slightly in ether and alcohol. Gives dark green with ferric chloride. It readily undergoes oxidation or condensation, giving a red product. According to Ultée and Van Dorssen it does not precipitate alkaloids or gelatine.

This is usual with a catechin. The cacao catechin and cacao tannin are closely related: Heiduschka and Bienert [69] consider that the tannin is derived from the catechin, but Nierenstein questions this [64]. If cacao catechin is boiled with water it ultimately becomes a tannin, or, according to Whymper, changes from a non-acid, non-astringent substance to an insoluble anhydride.

Cacao catechu tannin.—White amorphous colloid; insoluble in petroleum ether, chloroform or ether; easily soluble in cold water, ethyl acetate and alcohol. Gives a green colour with ferric chloride. It readily oxidises, forming a dark brown or black substance. Adam informs the author that it tans gold-beaters skin and is therefore a true tannin.

Catechin caffeine.—White needles. Melts at 83° C. and is somewhat unstable. This is a compound of cacao catechin and caffeine and is decomposed into these by boiling chloroform. Soluble in water: dissociated by boiling water. The percentage of caffeine in the fresh dried bean may be as much as 0·4 per cent. If it all exists in combination with catechin, the catechin caffeine would be about 1·0 per cent.

All these three substances are present in unfermented Criollo and Forastero cacao.

Cacao-Purple

The interior of the young bean in its very early stages of development, possibly up to three months, consists of translucent mucilage, but later it becomes opaque, white or coloured.

On plantations mainly Criollo, only a percentage of the beans in the pod appear to be absolutely white. In the case of Calabacillo *all* the beans show a purple section. Taking cacao as a whole we may say that in section the cotyledons vary from white or cream to many intensities of pink or purple owing to the presence of few or many purple pigment cells. The colour appears to be directly related to the botanic variety, but as the purple colour is dominant it will conceal an interbreeding of Criollo. The impression the author has is that the fresh bean before exposure to oxygen normally shows only one type of coloured cell and that is purple; it is only after oxidation that it shows brown patches. In any case the germ (radicle) is always white and originally contains no purple.

As this substance is purple both in the fresh bean and in the commercial product, the author proposes to call it cacao-purple. It is true that Fincke [70] has christened this substance cacao-red, but the author considers cacao-purple preferable as this more accurate colour description assists in distinguishing it from the oxidation products which are red-brown.

Cacao-purple is insoluble in petroleum ether, ether or chloroform; it is soluble in alcohol and water; the solution is purple when neutral, a bright pink when acid and green when strongly alkaline.

The colour changes which cacao-purple undergoes with change of hydrogen ion concentration are characteristic and striking. Moving in the direction of increasing acidity from neutrality ($pH = 7$), the purple colour suddenly becomes much feebler at $pH = 6$. Continuing, a change to pink occurs between $pH = 6$ and $pH = 5$. The colour becomes pinker and stronger at each step from $pH = 5$ to $pH = 2$, at which it is a powerful red. With increasing alkalinity the intensity of the purple increases, becoming a strong purplish-brown at $pH = 9$, a yellow-brown at $pH = 10$, and an intense green at $pH = 12$.

Whymper has suggested that the purple substance in Calabacillo beans is different from that in Forastero, and the author has seen purple and blue-purple cells in the same bean. Cheesman writes [72], "Almost certainly at least two white-seeded species, and probably two or more purple-seeded species have been involved" in producing the present varieties. The author realises that in writing simply of Criollo and Forastero he has assumed a simplicity which may not exist.

Cacao-Brown

Cacao-brown is not present in the fresh cacao beans as they are taken from the pod. The author has noted that the kernels of fresh unfermented Forastero beans when mixed with water give a faintly purple liquid which on exposure to air rapidly changes to the brown colour of weak tea. The purple colour is either completely destroyed or sufficiently diminished to be masked by the development of the cacao-brown. The brown colour is formed in a variety of ways, e.g. by fermentation and drying, the quantity present depending

on the kind and amount of tannins originally present and the amount of oxidation and condensation which has occurred. Cacao catechin, cacao catechu tannin and cacao-purple all readily form brown substances and what is sometimes called cacao-brown is probably a mixture. Cacao-brown is almost insoluble in water or alcohol, but is readily soluble in alkaline solutions. It is insoluble in ether, petroleum ether or chloroform.

Changes during Fermentation and Drying

We can now draw up a scheme indicating the tannins which are present and their changes during fermentation and drying :—

Tannic substances present in the fresh cotyledons.

Colourless.			Purple.
CATECHIN. (l-acacatechin).	TANNIN. (catechu-tannin).	CATECHIN CAFFEINE.	CACAO-PURPLE
↓	↓	↓	↓
Red-brown products.	TANNIN and dark-brown products.	CAFFEINE and red-brown products.	CACAO-PURPLE and brown products.

Tannic substances in cotyledons after fermentation and drying.

Briefly, during fermentation and drying the catechin is completely destroyed or altered to a red-brown product. The cacao tannin is partly oxidised to a cacao-brown. The cacao-purple is to a great extent changed to a cacao-brown. These statements are founded on the analyses published by W. B. Adam [68], who found cacao catechin, catechu tannin and catechin caffeine alike in Criollo and Forastero dried unfermented cacaos. He estimated the total catechin (free and combined) and the tannin. The free catechin and the combined catechin in the catechin caffeine undergo alteration during fermentation and completely disappear, so that although he found 0·8 per cent. catechin in unfermented beans (West African and Arriba) he found none in the fully fermented beans (West African, Arriba, Trinidad, Costa Rica, Bahia and Java). The alteration of the catechu tannin was only partial.

Whereas unfermented West African beans contained 2·37 per cent. of tannin and unfermented Machala 3·48 per cent., the fermented beans from West Africa, Guayaquil, Trinidad, Costa Rica, Bahia and Java, contained very similar amounts of catechu tannin, namely, about 1·9 per cent.

Tannins in Raw Dry Cacao Beans

	Unfermented.	Fermented.
Cacao catechin (free and combined) .	0·8%	Nil
Catechin caffeine	Up to 1%	Nil
Catechu tannin	2·4 and 3·5%	1·9%

The above figures are on the raw bean. Jensen [73] using the fully roasted nib and just neutralising the natural free acidity before estimation, obtained for commercially fermented beans higher figures (5·2 to 6·5 per cent.) for the tannin content.

Both investigators used the cinchonine process which, unfortunately, gives different results with solutions of different *p*H values.[1] Jensen extracted at 95-99° C. and Adam at 60° C. Both sets of results are comparative amongst themselves and both investigators found as much tannin in Criollo as in Forastero. This is not in accord with Kaden [83], who contends that the tannin content is closely related to the true botanic classification, the Forastero containing much more than the Criollo. Although there is no general agreement as to the quantities present, the evidence for the presence of the same catechin and caffeine catechin (and probably the same tannin) in both species appears conclusive and we are left with the cacao-purple to account for the darker colour and increased astringency which has often been noted in Forastero cacao.

As we have seen, cacao catechin, cacao catechu tannin and cacao-purple are soluble in water, whilst the brown oxidation products are almost insoluble. W. B. Adam informs the author that the taste of the catechin is only bitter and astringent for the first few seconds—the after-flavour is sweet.

[1] Oxidation products are possibly precipitated along with the tannins. "It may be significant that we have found that the tannins of cacao can be subjected to severe oxidation treatment without appreciably altering the amount of cinchonine precipitate given." (Norman and Hughes, *Analyst*, 1936, **61**, 304).

The catechu tannin and probably the cacao-purple are astringent. At one time it was believed that the oxidation products gave the cacao bean its characteristic taste, but both Sack [52] and Caspari (see Bainbridge and Davies [43]) have shown that these coloured bodies are odourless and tasteless.

The changes in colour which are observed during fermentation are firstly the distribution of the cacao-purple which tends to become less intense and more pink as the cotyledons pass from neutral to faintly acid. The colour of a transverse section through an Accra Forastero bean after three days' fermentation, that is just after the cacao-purple has been distributed, is purple. Using Ridgway's colour standard, Washington 1912, the colour varies from 59″ (Violet) to 65″ (Vinaceous-purple). On drying the section is heliotrope or purple. It undergoes little oxidation because the acidity of the cotyledons is now at its maximum. Secondly, after the third day, oxidation occurs, slowly producing insoluble browns from the colourless catechin and tannin and slowly converting any cacao-purple to brown. These changes of tannins to tasteless brown bodies result in a diminution of the astringency. As the purple substance is only slowly changed, it can often be seen tinting the brown in cacaos from Grenada and West Africa after six days' fermentation and subsequent drying. The quantity of cacao-purple present in the commercial cacao bean depends on :—

(*a*) Botanic variety: The amount of purple originally present varies from none upwards.

(*b*) Treatment: The amount of purple turned into brown by fermentation and drying varies from all to none.

Thus we find little in Java or good Ceylon cacao, which is nearly pure Criollo and well fermented; much in Guayaquil, which is Forastero and only slightly fermented; and a medium quantity in Grenada, which is Calabacillo but well fermented.

Whilst tannin and catechin become brown on heating, the author finds that the cacao-purple is not changed by exposure to ordinary roasting temperatures, up to 145° C.

Heinrich Fincke in his study [70] of the coloured substances in cacao beans has published with reservations the following provisional scheme indicating the relations of the substances (or groups of substances) allied to tannin in cacao.

Substance.	Treatment.	Product.
Parent Substance (Colourless)	*Process in the living plant?* or Treatment with alcoholic hydrochloric acid.	Cacao-purple
	Fermentation and Drying or Heat (roasting).	Cacao-brown
Cacao-purple	*Fermentation and Drying* or Addition of alkali (preparation of cocoa powder)	Cacao-brown
Cacao-brown	Treatment with alcoholic hydrochloric acid.	Cacao-purple

Where Fincke wrote cacao-red the author has written cacao-purple. Fincke's cacao-brown "parent substance" may be cacao catechin or a closely related substance. Both Forastero and Criollo cacaos show tannin-containing cells without fat and starch. In Forastero, as previously described, they are purple and in Criollo they are white. The Forastero variety possesses a special property: the power of producing cacao-purple. Steinmann [74] considers that light assists in the production of cacao-purple, although tannins are not generally regarded as being produced by photo-synthesis.

What is Cacao-Purple?

The cacao-purple, which makes the flesh of the fresh Forastero cacao bean such a wonderful colour, does not appear to have received the attention it deserves. Some of its properties are given above. The typical pink and purple colouring matters of plants are generally anthocyanins and are usually found in those parts of the plant which are exposed to light. Two purples found in parts devoid of light are those in red beet and in Forastero cacao beans. The purple red colour in beet contains nitrogen so it is not a typical anthocyanin. It has been suggested that anthocyanins may be derived from catechins. Cacao-purple resembles an anthocyanin in giving a red with acids and a blue-purple with dilute alkalis. It differs from many anthocyanins in that it does not lose its colour when dissolved in neutral alcohol and water. It resembles the tannins in being soluble in both water and acetone and in changing to brown on exposure to air. Whilst at neutral point, or if alkaline, it readily becomes oxidised; the change only occurs very slowly in an

acid medium. The author found that the juice of the pulp (*p*H 3·9) containing a little cacao-purple remained bright pink for five days at 50° C., which is a good temperature for the oxidase reaction. Whymper [44] illustrated its stability in acid solution in absence of the oxidase by boiling it in N/100 hydrochloric acid for five hours and obtaining no change.

In addition to the above, the author finds that on adding ferric alum to the purple juice and filtering, a colourless solution is obtained indicating that the cacao-purple has been changed by the iron salt. The author concludes that such evidence as we have suggests that this purple substance is a fairly stable tannin compound which is not so easily altered as the catechin.

Effect of Light on Cacao Beans

(*a*) *Cacao-purple in the cotyledons.*—Steinmann [74] has made a stimulating contribution on the subject of cacao-purple. He states that free cacao-purple is present in purple beans but not in white; and that the formation of free cacao-purple is dependent on light and is thus a photo-chemical process. If it is true, as Steinmann thinks, that there is a colourless substance which on exposure to light becomes purple, the observation is of great interest. In his experiment he took the cotyledons of fresh unfermented Java beans—presumably Forastero-Criollo hybrids—removed the pulp and then separated them into

(*a*) beans with a *white* section,
(*b*) beans with a *dark purple* section.

The beans showing intermediate pale purple sections he did not use. Both (*a*) and (*b*) after drying in the dark gave a slight yellow alcoholic extract. But after drying in the sun the dark purple beans gave a purple alcoholic extract, whilst the white did not. Steinmann does not state whether the cotyledons became *more* purple after exposure to the sun: if the purple did not increase then his experiment does not prove the photo-synthesis of the purple but that the exposure to the light made the purple alcohol-soluble.

At the author's request, F. Nicholas on the Gold Coast opened a fresh Forastero cacao pod in the dark and at once treated the beans with alcohol. He obtained a purple (wine

coloured) solution. Is it possible that in Steinmann's experiment it was not the light which synthesised, but the drying which destroyed the cacao-purple? Forastero cacao dried without fermentation in the sun shows to the eye the original cacao-purple as dark violet spots on an almost white background and gives a purple solution with alcohol. The author is indebted to F. Nicholas for preparing two lots of beans dried in the dark (1) with the pulp left on, at temperatures not exceeding 90° C., (2) with the pulp removed, but at temperatures not exceeding 35° C. These were sent to England in tins. In both samples the colour was distributed and changed and in neither case was the alcoholic extract purple. In Steinmann's test, the cacao was dried at 45-60° C., a temperature favourable to the oxidase and high enough to kill the beans and cause the colour to diffuse. This distribution and oxidation might account for the absence of purple in the alcoholic extract. But Steinmann then exposed these beans to sun-light and obtained from them a purple alcoholic extract. We must conclude that either the purple substance was synthesised by light as Steinmann states, or the cacao-purple was rendered alcohol-soluble.

The author was unable to confirm this using the Gold Coast cacao mentioned above. The beans dried in the dark at temperatures not exceeding 35° C. were (*a*) moistened with water or (*b*) crushed and moistened. Both whole beans and crushed were exposed to daylight for seven days and in neither case did they give a purple extract when treated with absolute alcohol.

(*b*) *Development of red-brown colour in shell.*—If the Criollo or Forastero unfermented bean is washed, the shell is almost white and when dried in the sun develops a rich red-brown (mahogany colour). It is evident that the shell itself contains some substance, possibly catechin, which on exposure to air and light develops this rich colour on the surface only. After fermentation the oxidation products of the tannins in the bean stain the inside of the shell and the pulp stains the outside so that the browns produced externally are darker and duller.

Steinmann has done some fascinating work on the production of a red-brown colour on the original white shell as a result of exposure to light. Red-brown on the shell is presumably due to oxidised tannins, so that either oxidation

is accelerated by light or a substance not originally present (cacao-purple or a suitable tannin) is produced by exposure to light. Steinmann compared the shell of the beans which were unfermented with beans which had been lightly fermented (that is to say for three or four days) and both of which had been washed. He found that his results were the same whether the bean was unfermented or lightly fermented :—

EFFECT OF EXPOSING SHELL TO LIGHT

	Unfermented or lightly fermented beans, exposed	*Colour of shell produced.*
1.	To sunlight or behind blue glass . .	Red-brown.
2.	To diffused daylight	White to brown.
3.	To ultra-violet light	White—unchanged.
4.	In the dark	White—unchanged.

In all the experiments the beans were warm, so that Steinmann came to the conclusion that the dark colour in the skins was not produced by heat or by ultra-violet rays, but that it was produced by sunlight. His experiments also showed that the depth of the colour was increased by acetic acid. Steinmann concluded that " a colourless fundamental substance is present which changes in (suitable) light either entirely or partly to cacao-red." By cacao-red he means what the author has here called cacao-purple. This explanation requires further proof, as the action which is accelerated by light may be the normal change in the colourless cacao tannins to insoluble red-brown substances. Autolysis in the dark appears to produce slowly a similar result for, if pods which have been preserved for some months are opened, the skin on the beans, on removing the pulp, is brown.

Whymper's Tannin Target

Whymper has proposed that the changes during fermentation should be studied in the field by noting the colours given by ferric chloride. It is unfortunate that the colours given by salts of iron are not specific to tannin but are characteristic of phenolic bodies. The author found that if ferric sulphate is added to the purplish liquid from the fresh beans one obtains a deep blue, or if oxidation has occurred, an olive green solution and dark green precipitate.

Whymper [44] produces colorations with ferric chloride in a picturesque form. He reverses the technique of Pliny

who soaked papyrus in a decoction of galls for the detection of iron, by spotting tannin-containing extracts on to ferric chloride test paper and obtaining what might be called colour targets. He obtains his extracts by boiling the kernels or skins in distilled water under standard conditions. In the case of Calabacillo cacao the fresh kernels give a circular patch with a black centre (diminishing in diameter as fermentation of the kernels proceeds) surrounded by a concentric pale purple zone (apparently diminishing in intensity as fermentation of the kernels proceeds) and an outer blue-green zone. This suggests to the author that there is present:

(1) In the pitch-black or blue-black centre some non-diffusable coloured substances, in part iron tannate, in part oxidised tannins.

(2) A water-soluble purple substance. This resembles the juice of the bean in colour. It is not cacao-purple but a compound of iron. The author noted that with paper soaked in iron alum no purple colour is produced at first; with ferric chloride the purple colour becomes more intense with age. Whymper records purple with Calabacillo, rose with Forastero and pale rose with Criollo.

(3) A soluble, readily diffusible, tannin giving blue-green with ferric chloride.

Whymper's test shows that as fermentation proceeds there is a decrease in the catechin or other substances giving coloration with ferric chloride. Beyond this the interpretation of the results is difficult. We can, however, deduce a few facts—that the cacao bean contains a constituent which gives a purple with salts of iron (blue-purple or red-purple according to the *p*H). Further, the intensity of this purple is related to the botanic variety, Criollo giving the palest colour.

Whymper, as mentioned above, has usefully applied his test to the skins and shown in a striking manner that whilst after one days' fermentation the skins of Calabacillo beans are still practically free from tannins which give colour with ferric chloride, on the third day they suddenly acquire considerable tannin from the cotyledons. This accounts in a simple way for part, at any rate, of the diminution of astringency in the cotyledons during fermentation. The extent of the diminution

due to this cause is conditioned by the skins being only a fraction of the weight of the cotyledons. Whilst Whymper's ferric chloride test indicated that the skins of unfermented Forastero beans are practically free from tannins, Fincke found a trace of cacao-purple and Steinmann's work on Criollo-Forastero hybrids and general observation indicate that a colourless precursor of a red-brown substance is present.

Theobromine and Caffeine

The valuable stimulant, theobromine, is not widely spread in nature. It can be found in tea leaves and in the kola nut. Its only important source is the cacao bean. Although it is present in amounts up to 0·5 per cent. in the young dried leaves of the cacao tree, they do not appear to have been used as a commercial source of theobromine.

Theobromine, free or combined, exists in appreciable quantities in the cotyledons of the fresh cacao bean, whilst the skin or shell contains, at most, a mere trace. It was for a long time assumed that fermentation produced or increased the theobromine in the cotyledons. R. V. Wadsworth and the author showed in 1924 [76] that, on the contrary, fermentation decreased it. As fermentation proceeds the temperature rises high enough to kill the bean and at once the liquid which permeates the bean dissolves the theobromine. Thus theobromine passes into the shell, so that using well-fermented beans of the Forastero variety one finds from 0·8 to 2·98 per cent. of theobromine in the dry shell, practically all of which has come from the cotyledons. Hence the longer the fermentation, the less theobromine will be found in cacao "nibs" [76].

The table below shows the loss of theobromine from the cotyledons and the gain of theobromine to the shell during ten days' fermentation of Forastero cacao in Trinidad. What happened in this experiment was that the theobromine diminished in the cotyledons and increased in the shell until about the same percentage (2·2 per cent.) was present in both when expressed on the dry fat-free material. In the case of Criollo cacao the period of fermentation is shorter and the transference of theobromine is less. Other nitrogenous substances besides theobromine are lost in comparatively large quantities, particularly if the fermentation is unduly prolonged.

Changes in theobromine content during fermentation

Period of fermentation.	*Shell.* Theobromine in shell (dry).	*Cotyledons.* Theobromine (on dry fat-free).	Total Nitrogen (on dry fat-free).
0 days	0·28%	2·96%	5·28%
2 ,,	+0	+0·09	+0·09
4 ,,	+2·07	−0·39	−0·23
6 ,,	+2·07	−0·60	−0·31
8 ,,	+2·05	−0·73	−0·44
10 ,,	+1·95	−0·74	−0·57

In the above experiment such a marked change took place at some period between two and four days that it became of great interest to know more exactly when the theobromine passed into the shell. Further experiments in Trinidad and Ceylon gave the following results :—

Changes in theobromine and caffeine content during fermentation
Cacao Shell

Period of fermentation.	Theobromine. Trinidad.	Theobromine. Ceylon.	Caffeine. Trinidad.	Caffeine. Ceylon.
hours	per cent.	per cent.	per cent.	per cent.
0	—	0·03	—	0·06
12	0·22	0·20	0·08	0·06
24	0·34	0·18	0·14	0·10
36	0·42	0·46	0·17	0·10
48	0·69		0·25	
60	1·23		0·40	
72	1·35		0·43	
84	1·42		0·38	
96	1·60		0·43	
108	1·47		0·40	

Judging from the above figures, the passage of both theobromine and caffeine from the cotyledons to the shell is very rapid at one particular period, namely, between 48 and 60 hours' fermentation. It will be remembered that this coincides with the period when the bean dies and the cacao-purple is suddenly distributed throughout the whole of the cotyledons. Incidentally it will be noted that the amount of theobromine and caffeine in the shell gives reliable information as to whether a cacao bean has been fermented or not. We have seen above, when discussing the analysis of the sweatings, that a little theobromine and caffeine pass from the beans into the sweatings during fermentation.

Few figures have been published relative to the caffeine content. There is about 0·4 per cent. of caffeine in the fresh

cotyledons. This is more soluble than the theobromine and after six days' fermentation is reduced to about 0·1 per cent.

How do Theobromine and Caffeine Exist in the Fresh Bean?

Hilger [77 and 82], Lazarus [78] and independently Schweitzer [79] found a glucoside, "cacaonine," which, according to them, during fermentation broke down yielding cacao-red, glucose and theobromine. Goris and Fluteaux [80], Ultée and Van Dorssen [65] and Wadsworth and the author [76] denied or doubted the presence of this glucoside. Later Jensen [73] and Fincke [70] also brought evidence against its existence. According to Sack [52] the glucoside is oxidised during fermentation into theobromine, glucose and cacao-red thus :—

$$\underset{\text{Cacaonine}}{C_{60}H_{86}O_{15}N_4} + \underset{\text{Water}}{8H_2O} + \underset{\text{Oxygen}}{25\ O} = \underset{\text{Theobromine}}{C_7H_8O_2N_4} + \underset{\text{Glucose}}{6C_6H_{12}O_6} + \underset{\text{Cacao red}}{C_{17}H_{22}O_{10}}$$

It has been noted above that the theobromine and caffeine appear to go rapidly into solution in the bean after two or three days' fermentation, whilst oxidation occurs later and is slow and continuous.

If all the theobromine in unfermented Forastero cacao existed as the above glucoside, then the dry fat-free nib would contain at least 20 per cent. of it. It will be remembered that during fermentation any sucrose present is inverted and that, in spite of this, increases if any in glucose are trivial. In other words, the sugar figures give no support to the glucoside theory.

The fact that both theobromine and caffeine are closely related substances suggests that the manner of their existence may be similar. As we have seen, Ultée and Van Dorssen [65] isolated from the Criollo cacao of Java a bitter-tasting substance which was not a glucoside and which has since been proved to be catechin caffeine. Adam, however, failed to isolate or synthesise a corresponding compound of theobromine. There remains the possibility of theobromine being combined with the catechu tannin. R. V. Wadsworth and the author [76] have tried several methods of estimating theobromine in both fermented and unfermented beans both before and after hydrolysis and the amount of theobromine found was no greater after hydrolysis than before. Either the whole of the theobromine exists as such or the compound

present decomposes with great readiness in the presence of the substances used in the estimation, e.g. in one method a weak alkali and in another damp chloroform. It is perhaps significant that it is not possible by any known method to extract completely the theobromine from dry cacao nibs with dry solvents. For complete extraction, water must be present [37 and 81]. On the other hand, the theobromine which has passed into the shell can be completely extracted with anhydrous solvents. It may be that the cell walls of the cotyledons, though pervious to water, are impervious to solvents like chloroform. Or the theobromine may exist as a very easily decomposable compound in the cotyledons which passes as theobromine into the shell. Possibly the compound which exists in the cotyledons is decomposed on contact with the acid liquid in the pulp (pH = 4). The solution and decomposition must take place rapidly, for the theobromine in the shell increases greatly in a few hours after the bean has died and liquid has permeated the bean.

It will be seen that the glucoside theory has received no support, but the possibility remains of the theobromine existing in the fresh bean as an easily decomposable compound. Fincke, who was unaware of our work, has from his own experiments [75] come to the same conclusion and suggests as Fritsch [60] did that the theobromine is probably combined with tannin.

Influence of Botanic Variety

The amount of theobromine found in the cotyledons of fermented commercial cacao depends not only on the losses which, as we have seen, increase with the period of fermentation, but on the amount originally present. Considerable variation in this is found in different kinds of cacao. Little is known concerning the variation in caffeine. R. V. Wadsworth has suggested that the amount of theobromine present depends on the botanic variety. From the figures of commercial and mostly therefore fully fermented cacaos that he has published [81], we can draw up the following table :—

Variety of Cacao.	Theobromine on dry fat-free nibs. *Per cent.*
Criollo (Venezuela, Samoa, Java)	2·2 to 2·4
Forastero-Criollo hybrids (Ceylon, Trinidad)	2·6 to 2·7
Forastero (Bahia, Accra, Haiti, San Domingo, Nigeria, Costa Rica)	3·2 to 3·8

It will be seen that the theobromine increases with the increase in cacao-purple. Also the lower the theobromine content the milder the flavour. The total xanthine bases on the other hand show little variation, thus Moir and Hinks [84] found on the dry fat-free nib from Samoa and Java, 3·17 and 3·16 per cent.; from Trinidad 3·16 per cent.; and from Bahia and Accra 3·07 and 3·37 per cent. respectively. Apparently there is more caffeine where there is less theobromine.

It is curious that Kaden's figures for theobromine [83] on the beans straight from the pod are in the reverse order to Wadsworth's. Kaden's results when expressed on the dry fat-free cotyledons are as follows:—

Theobromine in choice cacaos (Criollo) . . .	3·5 per cent.
Theobromine in ordinary cacaos (Forastero) . .	2·7 per cent.
Theobromine in ordinary cacaos (Calabacillo ?) .	1·7 per cent.

This apparent disagreement requires further investigation.

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(*To be continued.*)

TUNG OIL IN KENYA[1]

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AT the instance of the Imperial Institute, seed of *Aleurites montana* was first introduced into Kenya in March 1922 from Hong Kong and seed of *Aleurites Fordii* from Hankow, China, in July of that year. It is proposed to deal chiefly with *Aleurites Fordii* in this paper since very little seed of *Aleurites montana* has been planted in the Colony.

The original *Aleurites Fordii* seeds were sown at Nairobi,

[1] This memorandum was written for the East African Agricultural Research Conference held at Amani in February, 1936, and is published by kind permission of the Director of Agriculture, Kenya Colony.

at an altitude of 5,500 feet, in August 1922; in May 1924 the resulting trees were reported by the Conservator of Forests to be from 3 ft. to 5 ft. high. The germination of the early samples of seed was usually poor.

In 1926 the trees at Nairobi were from 5 ft. to 7 ft. high while others remained stunted at about 18 in. The average rainfall of Nairobi is about 37 in., but in 1925 only 22 in. fell.

The trees were attacked by *Aspidiotus* scale which was controlled by spraying. Two of the trees fruited in 1927 and a sample of seed was sent to the Imperial Institute for analysis. The report on the sample stated that the results of the analysis agreed closely with those obtained from the oil prepared at the Imperial Institute from the original Chinese seeds and from the oil prepared in China. The seeds produced in Kenya from seed of Chinese origin gave a similar or slightly higher yield of oil of the same character as that derived from the Chinese seed.

At a meeting held towards the end of 1927 the Imperial Institute Advisory Committee considered the possibility of extending the cultivation of tung oil trees within the Empire. East Africa was particularly mentioned in view of the favourable report which had been made on the seeds grown in Nairobi. A further sample of 15 lb. of *Aleurites Fordii* seed was obtained by the Economic Botanist, Royal Botanic Gardens, Kew, and forwarded to the Conservator of Forests, Nairobi, in February 1928. 20 lb. of Florida seed was sent in January 1929 and 20 lb. of Chinese seed in April. During the next two years considerable amounts of tung oil seed were distributed to farmers by the Forest Department while several farmers imported seed themselves. Interest in the crop was further stimulated in the Colony by the publication in June 1930, by the Empire Marketing Board, of the bulletin entitled "The Production of Tung Oil in the Empire."

Two small lots of seed were forwarded to the Imperial Institute from Nairobi in September 1932; these consisted of seed collected in June and July 1931 and in June and July 1932. The report of the analysis, submitted in March 1933, by Dr. L. A. Jordan, Director of the Research Association of British Paint, Colour and Varnish Manufacturers, was as follows:—

". . . The two samples were representative of the 1931 and 1932 crops grown at Nairobi, Kenya. The nuts arrived in a clean, dry condition, free from insects and pests. The physical examination gave the following results :—

	1931.	1932.
Average weight of nuts, *gms.*	2·80	2·93
Nut consists of—	*Per cent.*	*Per cent.*
Shell	41·2	37·5
Kernel	58·8	62·5
Moisture	6·3	6·4
Oil (solvent-extracted P.E. 60-80)	35·3	36·3
Oil, expressed on dry decorticated kernel	67·2	64·7

"The above figures would appear to accord with the average values observed for the species. Oil was expressed in the laboratory hydraulic press, and gave the following results on examination :—

	1931.	1932.
Colour (Lovibond 10 mm.)—		
Red	0·30	0·36
Yellow	1·0	1·4
Refractive index $n_D 25°$ C.	1·5181	1·5181
Density (25° C.)	0·9361	0·9358
Heat test	12½ mins.	12½ mins.
Acid value	0·6	0·4
Iodine value	167·7	168·0
Saponification value	192·6	194·4

"The gel obtained in the heat test was of satisfactory texture."

"The two oils appear to be of satisfactory quality, with very little difference between them. The slightly higher acidity of the 1931 oil may be ascribed to the storage of the fruit, though the difference in colour runs counter to expectation on this basis."

Questionnaires were issued by the Forest Department to growers of tung oil in 1933 and 1934. In addition to farm trials a few tung oil trees were tried at all Forest Stations.

The Department of Agriculture took over from the Forest Department the work on tung oil towards the end of 1935. Questionnaires were returned to the Forest Department in 1934 by some 70 growers of tung oil trees in various parts of the Colony. The Department of Agriculture sent out questionnaires to 52 of the growers whose previous reports had been amongst the more promising and to eight other growers in

the Trans Nzoia who had not received questionnaires previously from the Forest Department. Replies were received from 45 growers or 75 per cent. ; this response must be considered as very satisfactory.

The information given in the paper as to results of trials in Kenya is largely obtained from these questionnaires together with reports from various Forest Stations. Scrutiny of the questionnaires reveals the fact that there are now about 500 or 600 acres of tung oil trees cultivated in Kenya Colony ; of this acreage about 400 acres are in the Trans Nzoia district. The largest plantation in the Colony is at Longleat Estate, Kitale, where there are about 100 acres.

Climate

It appears that the most suitable districts for tung oil (*Aleurites Fordii*) in Kenya are at altitudes of about 6,000 ft. with a rainfall of 40 to 50 in. ; at altitudes higher than about 6,500 ft. the trees usually make very poor growth ; when the average rainfall is below 40 in. the trees tend to die out during the dry season.

Altitudes of less than 5,500 ft. seem particularly unsuited to the crop, while districts such as Kaimosi where the rainfall amounts to 60 or 70 in. or more are also unfavourable for the growth of tung oil.

Farmers in several districts complain of defoliation of the trees during the rains. Growth is best in the dry season in districts where the rainfall is heavy enough during the rainy season for some reserves of moisture to be accumulated in the soil ; one farmer at Kitale reports that his trees grew 2 ft. to 3 ft. during the 1934 dry season, growth ceased during the 1935 rains and commenced again with their cessation.

It is curious that a very high rainfall seems prejudicial to the success of tung oil in Kenya, whereas in the Southern Mississippi it is said that " climatic conditions are apparently good for the growing of tung oil trees, the precipitation being about 57 in. per year " (*Tung Oil Culture*, by Henry A. Gardner, January 1935). In Burma, also, the tree is grown under a rainfall of 69 in. per annum.

Soils

Little information is available as to the suitability or otherwise of the various soil types of Kenya. Poor soils with

a hard murram pan give bad results. Black cotton soils also appear to be unsuitable though, in this instance it may be the climate which is at fault. The plantations in the Trans Nzoia are chiefly planted on red sandy loams derived from gneisses and schists of the Basement Complex. The trees planted on the richer chocolate volcanic loams of Mount Elgon and Kiambu did not make better growth than the trees on the poorer soils.

Rate of Growth

All growers remark upon the extreme variability in the growth of the tung trees. One farmer in the Trans Nzoia, who planted the seed at stake, states that his trees, which are 3½ years old, vary in height from 1 ft. to 9 ft.

Many farmers observed that trees which are left in the nursery make far better growth than the trees which are transplanted; in one instance a tree is recorded to have grown 10 ft. during one year in the nursery. It is noteworthy, however, that the growth of trees on a 12-acre plantation which were planted at stake seems little if any better than that of transplanted trees. Probably the superiority of trees which have been left *in situ* in the nursery is explained by the more sheltered position, the better soil and perhaps access to water in the dry season.

The oldest trees in the Arboretum at Nairobi are now 13 years old and vary between 6 ft. and 20 ft. high. Some trees six years old are about 11 ft. high. While some trees are looking very well, others have died back to greater or less degree. This may be the effect of a succession of dry years, but more probably is due, at least in part, to disease; since dead and thriving main branches can be seen on the same tree. Some of these trees fruit fairly regularly but normally they have only a poor crop. Incidentally, complaints have been received from several farmers in the Colony, especially from near Nairobi in somewhat dry districts, of the periodic dying back of the branches of their tung trees.

Trees in the Colony in general vary between two years and six years old. The growth rate is extremely slow as a rule and averages only about a foot in height per year, the average yearly increase ranging between 9 in. and 18 in. Apart from the trees in the Arboretum at Nairobi, some of the oldest

trees are some in Songhor which are 7½ years old; these are growing at an altitude of 6,200 ft., the average annual rainfall being 58 in. The owner states that these trees are now 10 ft. high and have borne a few nuts; although the trees are very healthy the yield is said to be poor.

One of the more hopeful reports is from the Assistant Conservator of Forests at Muringato, Nyeri (6,000 ft., rainfall 37 in.), who states in his Annual Report for 1934 that tung trees planted in 1929 average 8 ft. 3½ in., the tallest tree being 16 ft. 6 in. He adds that the trees looked healthy and carried a fair crop of fruit during the year. The tallest trees at Longleat Estate, Kitale, are 9 ft. high with a spread of 7 ft. These were planted at stake in 1931. The average height is about 5 ft. 6 in. Flowers have hitherto been removed, but it is intended to allow the trees to fruit from now on. Some of the trees planted at stake in 1933 on a plantation near Kitale were some 8 ft. high at the end of 1935 when they were only 2½ years old. These trees have been given more attention than has been given to trees on most plantations in Kenya.

It has already been mentioned that in some districts it is complained that the trees suffer from excessive defoliation, especially in the rains, outside the periodic resting period which must occur if the trees are to make normal growth. It seems just possible that this defect sometimes may be due to the physiological condition known in the United States of America as "bronzing." This disease has been found to be due to a zinc deficiency in the soil and can be remedied by an application of zinc suphate to the soil or as a spray. In support of this hypothesis, as regards Kenya tung trees, is the fact that leaf diseases are said often to be rife during heavy rains when leaching out of minor elements would be most intense. It is intended to test this hypothesis by experiment.

Cultivation

It must be admitted that the trials of *Aleurites Fordii* in Kenya have not erred, as a rule, on the side of pampering the trees. In fact the methods of cultivation adopted have been in sharp contra-distinction to those in tung oil growing districts of the United States of America. In that country, for example, trees planted on poor soil have been planted in

large holes in which was placed 40 lb. of "muck" which had been dug from old lake beds. Trees planted with this aid are said to have made a growth of 6 to 8 ft. in five months. Only ten Kenya farmers or 22 per cent. of the 45 who returned questionnaires in 1935 stated that they have applied boma manure to the trees; one of these stated that the employment of cow manure and mulching gives a good response. One farmer applied a dressing of a quarter of a ton per acre of bone meal.

In America it is observed that "the importance of growing cover crops among tung oil trees cannot be over-emphasised." This method of soil improvement has been almost entirely neglected in tung tree plantations in Kenya where, however, physical or physiological damage may sometimes have been caused by the practice of inter-cropping the trees with maize. In many plantations the land has been allowed to become overrun with "couch." Only two growers reported having green manured their tung oil plantations and three growers reported that they mulched the trees, the latter farmers including a grower who mulches the green manure crops round the roots of the trees. In many instances damage has probably been caused by deep cultivation to the shallow root system of the tung trees on plantations in Kenya.

General Conclusions

It appears from the results of the trials made to date that *Aleurites Fordii* is not generally suited to Kenya Colony. The reason for this is not clear since the climate would seem to be somewhat similar—with the exception that snow and frost are absent—to the parts of China in which the tree is grown; possibly the trees suffer from the shortness of the hours of daylight in Kenya.

No figures are yet available for yields of nuts from plantations of any size which are at least five years old. Yields from a few scattered trees of bearing age are not very promising, but these older trees are chiefly in districts which are not likely to be suitable for the tree.

The general standard of the culture of the tung trees in Kenya seems to have been low, and ten acres of tung oil are to be established at Kitale by the Department of Agriculture in order to determine whether more intensive and careful

culture may give better results. One grower in the Kitale district reports that part of his plantation has grown much better than the rest; this circumstance will be investigated in the hope of discovering some clue as to possible relationships of the composition of the soil to the growth rate. It seems possible, however, that the superior growth of these trees—which are about 8 ft. high 2½ years after planting out—may be ascribed to the protection afforded to the tung oil by a belt of gum trees.

Reference has been made to the marked variation in growth of tung trees in the plantations in Kenya Colony. It is believed that this is due to the genetical variation which has been observed in other countries. Attempts will later be made to graft scions of the more vigorous trees on to root-stocks of the other trees or on to stocks of other species. A farmer in the Trans Nzoia notes that while the aerial growth of his tung trees is poor, the root systems seem to be well developed.

On the results of experimental plantations which have been made in Kenya Colony up to the present time no further plantings of *Aleurites Fordii* could be recommended; the plantations in the Trans Nzoia possibly may, however, cause these words to be modified during the next two or three years.

It is considered that extended trials should be made of *Aleurites montana*, *Aleurites moluccana* (or *triloba*) and perhaps *Aleurites cordata*.

Very few trials have been made of *Aleurites montana*, since it was thought originally that the climate of Kenya was likely to be much more suited to *Aleurites Fordii*. However, the Assistant Conservator of Forests, Eldoret, reported in 1934, that he had 20 trees of *Aleurites montana* in the Kisfim glade in Kakamega Forest, planted in 1932, which were 12 ft. high and in a flourishing condition. This station is at an altitude of 5,200 ft. and has an average annual rainfall of 70 in.

There are three or four trees of *Aleurites montana* in the Aboretum at Nairobi. Despite the fact that the rainfall at Nairobi probably is too light for this species these trees at present look quite well. The best tree is 12 ft. high and has a spread of about 10 ft. These trees are five years old from seed and fruited for the first time in 1935.

A very hopeful report was received from Sotik at the

end of 1935 with regard to several acres of *Aleurites montana* trees, seed and plants of which were planted in 1932, so that the trees are now 3½ years old. The trees were planted at an altitude of about 5,700 ft. and the average annual rainfall is probably about 54 in. It is stated that "We found that there was no comparison between the *Aleurites montana* and *Aleurites Fordii*. The *montana* has flowered prolifically and the growth is both even and quick, some of the trees being 17 ft. to 20 ft. high, whilst the *Fordii* are slow, stunted and uneven."

A tree of *Aleurites moluccana* (the candlenut tree) planted, probably in 1927, at the Scott Agricultural Laboratories, Nairobi, has made vigorous growth at an altitude of 5,700 ft., with an average annual rainfall of 40 in. over the last nine years. The annual rainfall is usually about 30 in. This tree was about 18 ft. high at the end of 1935 with a spread of 31 ft. It fruits fairly prolifically.

A farmer at Fort Ternan writes that he has a candlenut tree which is 30 ft. high and came into bearing within six years. This is at an altitude of about 4,900 ft. with an average yearly rainfall of 60 in. The oil obtainable from the nuts of this tree is said to be inferior to linseed oil for varnishes and similar uses. However, the tree, in view of its healthy and strong growth, might be of value as a stock on which to graft scions of the more valuable species of *Aleurites*.

There are also several candlenut trees in the Arboretum at Nairobi. They are about eight years old and have a height of some 30 ft. They fruit regularly but not freely. This tree is very pleasing in appearance and might be of value as a shade tree for paddocks. It is used in Brazil as a shade tree for cocoa; although it might prove to give too dense a shade it is certainly worth experimenting with as a shade tree for coffee in Kenya.

It is not believed that *Aleurites cordata* Steud., the source of Japanese wood oil, has been grown in Kenya.

NOTE.—Acknowledgements are made to the Conservator of Forests, Nairobi, for his kindness in giving the writer access to the files of the Forest Department dealing with the work on tung oil, and for being very helpful in discussing with him the subject of this crop; the thanks of the writer are also expressed to those farmers who kindly completed and returned the questionnaires.

SOME METALLIC AND INORGANIC COMPOUNDS USED AS WEED-KILLERS

The growth of weeds in cultivated crops is usually retarded, to a considerable extent, by the normal processes of agriculture, such as cultivation and rotation of crops. In many cases, also, weeds propagated solely by seed are checked by harvesting the crop before the weed-seeds are ripe. Some prolific annual weeds and certain perennial weeds in arable land and in pastures, however, cannot be kept down by these measures and during recent years the practice of controlling weeds by means of chemical weed-killers has spread rapidly, especially in countries where labour is scarce and expensive and agriculture is practised on an extensive scale, so that hand weeding or hoeing is impracticable.

The problem of the chemical eradication of weeds has many different aspects. In the case where weeds are mainly unsightly, as in paths, a weed-killer can be applied which is toxic to all vegetation and the effect of which may persist in the soil. With arable land lying fallow, the weed-killer used may also be toxic to all vegetation when it is applied, but the effect must pass away by the time a crop is to be planted. With weeds growing in a standing crop or in pastures, the weed-killer used should have the maximum toxic action on the weeds, while leaving the crop or the grass unharmed. Fortunately, the susceptibility of different plants to destruction by chemicals varies widely and in the case of cereal crops, where the eradication of weeds is often a matter of great importance, the crop plant is protected to a considerable extent by the narrowness and erect habit of its leaves and by a certain "waxiness" of surface which makes them difficult to wet, unlike the broad and often hairy leaves of many weed species. In pastures, also, the grass is usually more resistant than the weeds to the action of chemicals. In many cases, the crop or the grass may be temporarily injured or retarded in growth by the chemical used, while the weeds are killed more or less completely.

In the choice of a suitable weed-killer account should be taken of a number of factors. It is found that a particular chemical may kill one species of weed, while on another species it may have but little effect. The stage of growth

plays a part and it has been found that certain weeds are most susceptible in the seedling or the very young stage, whereas with others and with different weed-killers, it is better to apply the chemical when the plants have reached the flowering stage. The efficiency of a weed-killer may be affected by the relative stages of growth of the weeds and of the crop, e.g., one may protect the other from the action of a spray. Climate, weather and soil conditions are all important; some weed-killers are most effective if applied on a dry sunny day, while a damp moist atmosphere is better in other cases. Some weed-killers if sprayed on to the leaves are readily washed off by rain falling soon after their application and hence may be without effect, but the action of others is unaffected by rain.

The possible danger to human life or to stock from a weed-killer must also be considered. For instance, arsenic compounds are all highly poisonous both to man and to animals, so that care must be taken not only during the handling of an arsenical weed-killer but later also in order to prevent stock from eating vegetation to which such a substance has been applied. Sulphuric acid is very corrosive and must be handled and diluted for use with care, and, in certain circumstances, the use of chlorates may involve grave risks of fire and explosion.

There is the possibility that a weed-killer may have an immediate or a residual effect of an adverse character on soil processes such as nitrification, or on the physical properties of the soil. Thus, the use of large quantities of sodium salts on a heavy soil may render it difficult to work owing to the saturation of the base exchange complex with sodium ions, a process which makes the clay fraction of the soil difficult to flocculate. The chemical used may also tend to accumulate in the soil, so that repeated treatment may render the soil toxic to crops.

The removal of a part only of the weed population by means of a differential weed-killer may have an indirectly stimulating effect not only on the crop, but also on the weeds left uninjured, owing to the reduced competition.

All these factors, in addition to the question of cost, availability of supplies and ease of application, have to be taken into account in considering which is the most suitable weed-killer to use.

A short account of various chemicals used as weed-killers is given below. These substances are, as a rule, manufactured primarily for industrial purposes or obtained as by-products; with the exception of some chlorates, they are not specially made for weed-killing.

Copper Sulphate (blue vitriol)

One of the first chemicals used for weed control in crops appears to have been copper sulphate and the use of this substance is said to have come about fortuitously. A French vine-grower observed that copper sulphate (used as a fungicide on the vines) killed charlock and mustard growing amongst the vines, while oats in the same position were unaffected. Since that observation, copper sulphate, generally used in solution as a spray, has been very extensively employed as a weed-killer, particularly for the eradication of weeds such as charlock, among cereal crops. The crop may be temporarily retarded, but this effect soon passes off. Climatic conditions play an important part in deciding the strength of the spray solution and the quantity needed per acre. The destructive effect of copper sulphate on weeds appears to be related to the amount of the spray actually retained on the leaves and it is, therefore, desirable that there should be no rain for a period of about 24 hours after the application of the spray.

The susceptibility of weeds to the action of copper sulphate varies considerably. This chemical cannot be used for weed eradication in root-crops, such as turnips, as these plants, belonging to the same natural order as charlock and mustard, are as easily injured by the spray as the weeds.

In places where water is difficult to obtain, copper sulphate may be applied in the form of a fine powder. In this case, it is generally mixed with an inert filler such as fuller's earth in order to facilitate spreading, and should preferably be used early in the morning while the dew is still on the leaves.

So far as information is available, there appears to be no danger to crops from accumulation of copper compounds in the soil, as the salts added seem to be absorbed by the soil and do not reach the roots of the crop-plants in a soluble form.

A special use for copper sulphate is its application in minute amounts to potable water supplies liable to growths of algæ,

which are thereby killed or prevented. (Thresh, Beale and Suckling, *Examination of Waters and Water Supplies*, 4th Edition, London, 1933.) The concentration used must be extremely small, less than 1 part of copper sulphate per million parts of water, but this small amount is sufficient for the purpose. The copper is precipitated in an insoluble form during the subsequent processes of purification and filtration and does not reach the consumers.

Ferrous Sulphate (copperas or sulphate of iron)

This salt is used extensively as a weed-killer, especially in America. It is employed either in solution or, less commonly, as a fine powder. It is less toxic than copper sulphate, so that although the initial cost is lower than that of copper sulphate, four or five times as much is usually needed to bring about similar results,and so there is not much difference in the cost of eradication. It is less easy to employ than is copper sulphate and is liable to oxidise on keeping. The species of weed to be killed and its stage of growth markedly affects the effectiveness of ferrous sulphate, young weed plants being as a rule much more liable to injury than older plants. It is, however, found to be more effective than copper sulphate on some species of weeds.

Ammonium Sulphate

Ammonium sulphate has, in recent years, been used extensively as a weed killer. For this purpose it is applied either in solution as a spray or as a fine powder. Its selective action on certain weeds is marked, while others are little affected. It appears to be especially effective in killing weeds of a rosette habit of growth, its potency depending on the amount of spray or dust actually retained on the leaves. Recently some experimental work has been carried out on the effect of the addition of a " spreader " or " wetter " to an ammonium sulphate spray for the eradication of certain troublesome weeds from grass. (Engledow and Woodman, " Use of a Wetter in Weed Spraying," *J. Minist. Agric.*, 1935, **42**, 663.) The spreader used in order to increase the adherence of the spray to the weed-leaves was, in this instance, soft soap, and although difficulties were encountered because of a salting out effect of the ammonium sulphate on the soap

solution, the trials showed that the addition of a spreader of some kind increased the weed-killing efficiency of the spray.

Ammonium sulphate also has been particularly recommended for use in cereal crops against certain weeds such as corn buttercup, hoary pepperwort and spotted medick, which are not easily eradicated by the more usual methods of treatment. The quantity applied is generally from 1½ to 2 cwt. per acre, but more may be used in special cases. It must not be used with most leguminous crops as it injures them.

The residual effect of ammonium sulphate is, of course, that of a nitrogenous fertiliser to the crop. In cases where the soil is already adequately supplied with nitrogen, this may be a disadvantage, as, in some cereal crops, e.g., barley for malting purposes, the quality of the crop is of more importance than the quantity and the former is adversely affected by excessive amounts of a nitrogenous manure.

Sulphate mixtures

Mixed sprays, of copper sulphate and ammonium sulphate, are sometimes used, particularly for certain resistant species of weeds.

Nitrate of soda has been tried at various times as a weed-killer, but its action is said to be too uncertain and variable for its use alone to be recommended. Mixed with copper sulphate, however, it has found some application for use against special weeds. Probably the main effect of the nitrate of soda is to stimulate the growth of the crop, so as to enable it to outstrip and smother the weed growth.

Ferrous sulphate has been tried in the form of a solution reinforced with 5 per cent. of sulphuric acid, for the destruction of weeds which resist the action of ferrous sulphate alone (Woods and Bartlett, *Exp. Sta. Rec.*, 1909, **21**, 424), but this mixture has never been widely adopted.

A mixture of ferrous sulphate and salt, applied dry to the crown of each plant, was at one time used in attempts to destroy ragwort in New Zealand pastures, and was found to have some effect, but has now been largely superseded for this purpose by sodium chlorate.

Recently a somewhat specialised use has been made of ferrous sulphate in its employment as a weed-killer for

grass swards, such as lawns and golf greens, where a close growth of fine grasses is desired, in addition to freedom from weeds. For this purpose, it is generally used mixed with ammonium sulphate and is applied at short intervals during the growing season. It should be watered in, so as to avoid scorching the turf. It is probable that this mixture acts in two different directions, the ferrous sulphate as a weed-killer and as a stimulant to the finer grasses and the ammonium sulphate as a stimulant to the growth of grasses and as a depressant to the growth of weeds, particularly those of the rosette type. There is also a tendency for these two salts to render the reaction of the soil more acid and this would help to retard the growth of clover.

Investigation work in this direction has been widespread, not only in Great Britain, but in South Africa, New Zealand and Australia. In some cases the addition of ferrous sulphate to a complete mixed fertiliser has been found to give the best results in turf production, both as regards the formation of the sward and freedom from clover and weeds. (Moses, "Fertility and Soil Reaction in Turf Production," *S. Afr. J. Sci.*, 1934, **31**, 288.)

Other Copper Salts

Copper nitrate has been used to a small extent as a spray for weed eradication and is said to be effective against certain species of weeds, while oats and red clover are not affected. The nitrogen present would have a fertilising effect on the crop, but the cost of this salt is too high for it to find extended use as a weed-killer.

The use of dehydrated water-soluble copper salts as weed-killers is specified in a recent German patent (*Chem. Tr. J.*, 1935, **96**, 320). The salts must be capable of being dehydrated so that they can be ground to a fine impalpable powder, which can be applied to the plants as a dust by means of an atomising apparatus. Various copper salts, such as copper sulphate (dehydrated at 100° C. so that it still contains one molecule of water of crystallisation), copper chloride, copper fluoride and copper ammonium chloride may be used, either alone or in admixture. Field trials in Germany are said to have shown good results with some of these dusts on various species of weeds.

Zinc Sulphate

This compound is not much used for weed-killing, it is highly poisonous to many plants and offers no general advantages over copper sulphate. It has, however, been employed for a number of years, both in America and in Sweden, in special circumstances, namely, for weed-killing in nursery seed-beds of coniferous seedlings, and has been found to be highly effective for this purpose. It appears to have a less injurious effect on the coniferous seedlings than copper sulphate, while being a more efficient weed-killer.

Zinc sulphate appears to be effective only in preventing germination of weed seeds; it does not usually kill weeds already growing. The amount applied has to be regulated with extreme care in order to obtain the desired results and at the same time to avoid damage to the conifers, which seem to be relatively resistant to its poisonous effects. It tends to accumulate in the soil, so that dressings subsequent to the first have to be reduced in amount in order to avoid damage to the seedlings. It does not appear to be likely to be of general applicability.

Kainit

This substance, when marketed as the familiar low-grade potash fertiliser, is a mixture of chlorides of potassium and sodium with magnesium sulphate. It has been extensively used, particularly in Germany, as a weed-killer, especially against charlock in cereals. It is applied as a fine dust in the early morning while the dew is still on the leaves. Relatively heavy applications are usually recommended and the treatment is, therefore, expensive. Hence the use of kainit has recently been to a large extent superseded by that of cyanamide or sulphuric acid, although it is valuable on light soil deficient in potash, where its fertilising action comes into play and helps to offset the cost of the treatment.

Arsenic compounds

These substances have been in use as weed-killers for many years and a large number of proprietary weed-killers on the market contain, as the active principle, either sodium arsenite or a mixture of an alkali and arsenious oxide. Their usefulness is, however, limited mainly to the destruction of weeds in

uncultivated ground, as they tend to persist in the soil, rendering it barren. Arsenic compounds also accumulate, so that the use of an amount which is safe as a single application cannot be repeated. They are sometimes used for clearing arable land of weeds in autumn, no crop being planted until the following spring. They cannot be recommended for general use, but in some circumstances may be preferable to other weed-killers.

A disadvantage in the use of sodium arsenite or alkaline arsenious oxide weed-killers lies in the fact that they may have an adverse effect on the physical properties of the soil.

The chief drawback to the use of arsenical compounds, however, is their highly toxic character to man and animals, so that great care must be exercised in their storage and handling. In consequence of this, recommendations have been made to the manufacturers of such weed-killers, advocating the addition of a small quantity of a blue dye, in order to obviate danger of mistakes.

A special use of sodium arsenite, analogous to weed-killing, has been developed in Australia, where this compound is employed for killing green timber during the clearing of land. (Meadley, " Sodium Arsenite as a Weedicide," *J. Dep. Agric., W. Aust.*, 1934, **11**, 2nd series, 521.)

A large amount of work has also been carried out in Australia on the eradication of prickly-pear, which is a serious pest in parts of the country. During 1912-1915, a variety of chemical substances, including arsenic mixtures, sodium, potassium and barium chlorates, copper sulphate, potassium dichromate and potassium thiocyanate, were tried, either as sprays, injections or dusts. (*Rep. Prickly-Pear Exp. Sta. Dulacca* (1) up to April 30, 1914; (2) May 1, 1914, to April 30, 1915. Published respectively as *Appendix IV, Rep. Dep. Publ. Lds. Queensld.*, 1912-13 and 1914.) Many of these were found to be more or less injurious to the plants, but considerations of effectiveness combined with costs, supplies and ease of handling, led to the use in the main of arsenic preparations for the purpose.

Arsenic pentoxide is sometimes used as a weed-killer, but its action is slower, in general, than that of arsenite compounds. It has, however, been found that aqueous arsenic pentoxide, i.e. an aqueous solution of arsenic acid, emulsified in cresylic

acid by means of a small proportion of glue, is one of the best chemical treatments for the eradication of prickly-pear, as the arsenic acid is very destructive to the weed and the cresylic acid by its smell deters animals from eating the treated plants.

Arsenic pentoxide has also been tried as a weed-killer for lawns and greens where a close growth of grasses only is desired. When applied in solution, it turns vegetation brown, but as it is generally used in the autumn when the grass is, in any case, likely to be a poor colour, this is not a serious drawback. The grasses usually recover in about three weeks, while the weeds are more or less killed. In very weedy turf, bare patches are thereby left and are liable to invasion by weed-seeds, so that re-seeding of these patches with grass as soon as possible is necessary. Arsenic pentoxide is said to have the advantage over sodium chlorate that it does not favour the return of clover on the treated turf, and the dangers attending its use are better known and of a different character from those of chlorates.

Chlorates

The use of chlorates as weed-killers has been the subject of numerous investigations in many parts of the world and a short account of the earlier experiments has been given by Åslander (*J. Agric. Res.*, 1928, 36, 915). The first recorded experiment with chlorates as weed-killers appears to have taken place in 1901 (*Queensld. Agric. J.*, 1901, 9, 460), but few further trials were made until recent years, when these compounds have been extensively employed. Sodium chlorate has been used mainly as it is cheaper and easier to obtain than other chlorates, but potassium, calcium, magnesium and to a small extent barium, chlorates have also been tested.

The weed-killing effect is believed to be due to the chlorate ion or to the amount of available oxygen present, as the action of chlorates on foliage is mainly one of burning, but when the chlorate reaches the soil, there is also a certain amount of root-poisoning effect. The susceptibility of plants to destruction by chlorates varies considerably. Chlorates are used mainly as weed-killers on perennial weeds, as their effect persists in the soil for varying periods up to several months after application. They are also stated to have an

important residual effect in the soil, by retarding the process of nitrification.

In this country, chlorates, mainly sodium chlorate, have been used chiefly for the destruction of perennial weeds in arable land lying fallow. Sodium chlorate has been found to be very effective for this purpose on many types of weeds, although a number of weeds with deep fleshy roots are not eradicated by its application. It is considered best to apply the chlorate in the autumn, the land being usually fit for planting to a crop in the following spring. Application of chlorate in the spring is not so good, as its effect on the weeds is less than in autumn and the land cannot be safely planted with a crop in the following autumn. Spraying with chlorate solutions is most effective if carried out in three or four applications at intervals, rather than by one large application and, as a rule, becomes more effective as the weeds reach the flowering stage.

Spraying with weak solutions of sodium chlorate, of about 2 per cent. concentration, has been tried in a few cases on annual weeds growing in cereal crops, but this is attended with grave risk of damage to the crop and cannot yet be considered as being in more than the experimental stage.

Chlorates have been tried in America to a considerable extent and it has been shown that the toxic amount varies with different weed species and is also affected by weather and other factors, such as its use under dry farming, irrigated or humid soil conditions.

One of the most extensive investigations on the use of chlorates has been carried out in New Zealand. The occurrence of ragwort in many New Zealand pastures presents a very serious problem to the stock-farmer, as this weed is found to have, on cattle eating it, a slowly cumulative poisoning effect, which cannot be cured by moving the affected stock to ragwort-free pastures. Many attempts have been made to find a weed-killer for eradicating ragwort and so far, the most effective treatment has been the application of sodium chlorate, either as a spray, or mixed with inert fillers, as a dust. Spraying with a 5 per cent. solution when the plants are at or near the flowering stage has been found very effective. The treatment has to be repeated at intervals in order to kill off subsequent growth of weeds from seed. The grass of the

pasture is often badly scorched by the treatment, but soon recovers.

Unfortunately, possible dangers which might arise with the use of sodium chlorate were not realised during the early stages of its use as a weed-killer, and there have been a number of serious and even fatal accidents, particularly in cases where boots or clothing saturated with sodium chlorate spray have been allowed to dry and have subsequently become ignited by heat or friction. There have also been cases of spontaneous ignition of vegetation saturated with chlorate spray and subsequently dried by the sun. The precautions which should be taken when using sodium chlorate have been very well described by Aston and Bruce (*N.Z. J. Agric.*, 1933, **46**, 230) and it is stated that if these are carefully observed there should be little danger.

Owing to the fact that most of the accidents resulting from the use of sodium chlorate have occurred when using solutions of the salt, the application of chlorate as a dry dust appears to be extending. The chlorate, finely powdered, is diluted with a filler or spreader, so that it forms from 5 to 10 per cent. of the final mixture, and this is either broadcast over the whole area or dusted on to the weeds. It is stated that almost any finely powdered dry mineral matter may be used as a spreader, provided that it does not contain organic matter, sulphur or free acid. Limestone, basic slag and ground rock phosphate have all been used for this purpose.

Attempts have also been made to reduce the possible dangers of sodium chlorate by mixing it with a deliquescent substance, such as calcium or magnesium chloride, and by using calcium chlorate, either alone or mixed with calcium chloride, as a substitute. Calcium chlorate is less readily obtainable than the sodium salt and it is also not quite so effective, but the risks of fire and explosion from its use are somewhat less. Recent investigations in Canada appear to indicate that mixing the chlorate with a deliquescent salt is an excellent method of reducing the fire hazard, which is dependent to a considerable extent on the relative humidity of the atmosphere. The chlorate present in such a mixture, however, appears to be less effective than the same amount of chlorate applied alone.

Potassium chlorate, yielding an amount of available

oxygen equivalent to that in sodium chlorate, is almost as effective in action, though a rather larger actual quantity is required, and it also has the advantage of supplying potash to the soil. It does not adversely affect the soil for so long a period after application as does the sodium salt, but requires similar precautions in use.

Barium chlorate has been tried on a small scale and in equivalent amounts is said to be at least as toxic as the sodium salt.

Efforts are being directed, especially in New Zealand, to finding a substitute for sodium chlorate, which will be equally efficacious as a weed-killer while being free from the dangers of that compound.

It may be of interest to note that sodium chlorate is one of the few substances which are now being manufactured primarily for use as a weed-killer.

Calcium Cyanamide

This well-known nitrogenous fertiliser is usually referred to as cyanamide, or, by the farmer, as lime-nitrogen. In addition to its value as a fertiliser it is widely used as a weed-killer, not only in Great Britain, but in most European countries and in America. Its use for this purpose appears to be increasing and it is stated that the amount used in Germany for weed destruction has been more than doubled during recent years.

Calcium cyanamide is usually supplied as a fine powder and being insoluble in water is applied as a dust. It is generally recognised that it is a rather unpleasant substance to handle.

The effectiveness of cyanamide as a weed-killer in crops depends largely on the time of application, the season and the relative stages of growth of the weeds and the crop, as well as on the species of weed. Cases have been recorded where it had little or no effect on the weeds and there are instances of severe damage to the crop. It is, therefore, usually recommended that trial should first be made on a small area.

On arable land, it is usually considered best to apply cyanamide a week or more before sowing seed. Weed seedlings are then destroyed and the crop receives the full benefit of the added nitrogen. Cyanamide is also very frequently

applied as a top-dressing to cereals and occasionally to other crops. It should be used early in the season, while the weeds are still in the seedling stage and the crop is well started. Broadcasting on a calm day while the plants are still wet with dew is usually recommended. The cereal crop is often browned by the action of the cyanamide but usually it recovers quickly and there is no delay in the date of maturing of the crop. The remarks made above under ammonium sulphate, regarding the effect of added nitrogen on cereal crops, are equally applicable here.

Calcium cyanamide has also been used on grass land, when it should be applied in the early spring, before active growth of the grass begins. The weeds are thereby killed and although the existing grass may be temporarily scorched, the new growth shows marked stimulation from the added nitrogen. It is considered advisable to keep stock away from grass treated with cyanamide for a few days, until heavy dews or rain have washed it off the herbage.

Ammonium Thiocyanate

This compound, also called sulphocyanide, occurs in the crude gas liquor obtained during the purification of the gas at gas-works and coke-ovens. It has been tried as a weed-killer during recent years. It may be used either as the separated salt or as the active constituent of the crude liquor, and is generally applied in solution as a spray, but for the eradication of large weeds or shrubs, the dry salt may be used, being spread round the base of the plant. It is stated that when a crude liquor is used, still containing tarry matter, the effect is more lasting than when the pure salt is employed.

When used on cultivated land, ammonium thiocyanate renders the soil unfit for a crop for some time, although it is said that if it is applied two or three weeks before sowing seed, e.g., of wheat, the weeds are effectively reduced while the crop is unaffected. In other cases, however, it has been found advisable to leave the soil fallow for some months after the application of ammonium thiocyanate and in some preliminary experiments in Canada, its use is said to have ruined the crop completely.

On pastures and meadows, ammonium thiocyanate has a marked effect on the grass as well as on the weeds, but the

grass usually recovers within two or three weeks. It is said to favour the return of certain species of weeds. In New Zealand, ammonium thiocyanate has been tried recently as a substitute for sodium chlorate in the eradication of ragwort from pastures, and gives promise of being suitable for this purpose, although its action is slow compared with that of chlorates, the actual death of the treated weeds not taking place in some instances for some weeks after spraying.

Ammonium thiocyanate has, in general, a residual manurial effect owing to the nitrogen present.

Sodium thiocyanate has also been tried on an experimental scale, but does not appear to be so effective as the ammonium compound. In some early trials it was found that sodium thiocyanate decomposed so rapidly in contact with the soil that it had very little value as a weed-killer.

Sulphuric Acid

The earliest trials of sulphuric acid as a weed-killer are stated by Rabaté ("Use of Sulphuric Acid against Weeds and certain Crop Parasites," *Int. Rev. Sci. Pract. Agric.*, 1926, New Series, **4**, 535) to have been made in 1898 in France. Although the first experimenters then concluded that it could not be used in practice, trials were renewed a few years later, largely by Rabaté himself, with more satisfactory results, so that for the past twenty years the use of sulphuric acid as a weed-spray has been steadily increasing, especially in France, Scandinavia, the U.S.A., and Germany. In France the area sprayed in recent years is estimated at about half a million acres and the quantity of acid used as over 20,000 tons per annum. Co-operative arrangements for sulphuric acid spraying are frequently made in European countries by agricultural associations.

In Great Britain, spraying with sulphuric acid has been carried out for only a few years, but the practice has been found to be so successful under certain conditions that the consumption of sulphuric acid for this purpose is rapidly increasing. The area sprayed with sulphuric acid in this country was estimated at 200 to 300 acres in 1931, by 1933 it had risen to over 5,500 acres and in the spring of 1935 is said to have exceeded 29,000 acres (*Chem. Tr. J.*, 1935, **97**, 408.)

The increased use of sulphuric acid in recent years may be attributed partly to the better acid-resisting machinery, especially for spraying, which has become available. In this country, also, experiments with sulphuric acid for spraying purposes have been carried on not only by agricultural research institutions, but also by, or at the instance of, manufacturers of the acid, who in certain cases make arrangements to loan the requisite spraying machinery to farmers, or to do the spraying by contract.

During the earlier trials with sulphuric acid, comparatively weak solutions, usually from 1 to 4 per cent. by volume, were used, but more recently the strengths of solution used have been increased, so that acid from 7 to 10 or even 12 per cent. by volume is now generally employed. In special circumstances, the strength may even be as high as 20 per cent. The nominal percentage strengths of acid used in this country and abroad are the same, but the concentrated acid used on the Continent is usually 65° Bé., which contains 90 per cent. by weight of pure sulphuric acid, whereas in this country the concentrated acid used is the unrefined "Brown Oil of Vitriol," which is about 60° Bé., and contains 77 per cent. by weight of the pure acid. Actually, therefore, the English solutions are rather weaker than those used on the Continent, but they have been found entirely satisfactory in use.

The use of sulphuric acid as a weed-spray will not be likely to have any adverse residual effect on the soil, as the spray contains no elements which might not occur naturally in soil, but at first sight it does appear to involve risks of rendering the soil excessively acid. The spray, however, is generally used at the rate of 100 gallons per acre, and if a 7 per cent. solution is employed, this is equivalent to the addition of 7 gallons of "Brown Oil of Vitriol" to the soil per acre. This amount of acid can readily be calculated to require 93·5 lb. of carbonate of lime to neutralise it, i.e. less than one cwt. of limestone or half a cwt. of quicklime per acre. Such a degree of decalcification would be negligible in a calcareous soil, but on acid soils, repeated spraying would need correction by liming, although the amount of lime required would be little more than that applied normally in the course of good agricultural practice.

It was at one time considered that the addition of small

quantities of sulphuric acid to the soil was instrumental in rendering additional quantities of plant nutrients, such as potash and phosphoric acid, more readily available for plant nutrition, but the evidence on this point from controlled field trials is now considered to be inconclusive. Spraying does not always give an increased yield and there have been insufficient trials made to decide whether there is any manurial effect from the sulphuric acid.

By far the most extensive use of sulphuric acid sprays is for the destruction of annual weeds in cereal crops and for this purpose they may be used either in spring-sown or autumn-sown crops. It appears that sulphuric acid does not have the same kind of selective action on weeds as do some other weed-killers and there is no poisoning effect. The weed-killing properties are believed to be due to the withdrawal of water from the plant tissues, leading to rapid withering and death of the aerial parts of the plants. Weeds and crop-plants are found to vary in their resistance to sulphuric acid sprays, the strength of acid required to effect a complete kill being higher with some weeds than with others. This appears to be due mainly to the physical characters of the different plants, such as thickness or waxiness of cuticle, and also to the position of the delicate growing shoot. When applied to weeds in a cereal crop, the cereal plants are affected by the sulphuric acid, their outer leaves becoming brown and withered, but the growing tip of the cereal is protected by the outer leaves being wrapped round and over it and hence is unharmed by the acid. The cereal crop, therefore, recovers from the effects of the spray. For the same reason, weeds of a grass-like character are not killed by sulphuric acid sprays.

On deep-rooted perennial weeds, the effect of sulphuric acid spray is to kill all the aerial parts, but the roots remain unaffected and will send up further shoots later in the season. These late shoots are usually small and weak and often do not set seed. The retarding action of the spray on them also enables the crop to become well-grown before the weeds and so to reduce the weed growth further by a smothering effect.

To obtain the maximum result, spraying should be carried out when the weeds are young and at a rapidly-growing stage. They are then more susceptible than at a later stage of growth. The cereal crop should preferably be only a few inches in

height. It is also possible to spray the weeds either before the seeds of the crop are sown, or soon after sowing provided this is done before the crop seedlings have appeared above ground. If spraying is left too late, the crop may receive such a severe check that it does not recover satisfactorily.

The effect of the acid spray is very rapid and usually within two or three hours after spraying the whole area appears brown and withered. Hence rain soon after acid spraying is not the serious disadvantage that it is with copper sulphate spraying. Acid spraying has even been actually carried on during slight rain with good results, although warm, dry weather helps to accelerate the effect of the acid spray by increasing the evaporation of water from the leaves and so raising the concentration of the acid in contact with them.

To obtain the best results the use of a very finely divided spray is essential and this must be applied with some force. A number of special spraying machines have in consequence been devised for this purpose, the spray being produced by various pressure systems.

Sulphuric acid sprays have been used on a small scale for weeds in crops other than cereals, such as potatoes, sugar-beet and flax, but success in these cases appears to depend on choosing exactly the right time to spray, so that the weeds are killed with the minimum damage to the crop, and the process cannot be recommended for general adoption. A few trials have also been made on spraying weeds in grassland, but though the grasses and the weeds all appeared to be badly affected at the time of spraying, all recovered from the effects of the spray, so that at the end of the growing season the sprayed plots could not be distinguished from those left unsprayed.

Although not normally regarded as a weed, the infestation of grazing land by bracken in certain parts of Scotland presents a serious problem, especially as the bracken, if undisturbed, spreads rapidly. It can be controlled to some extent by repeated cutting, but this is troublesome and expensive and does not eradicate the plant. Trials carried out some years ago by Gordon ("Bracken, *Pteris aquilina*: Life-history and Eradication," *Trans. Highl. Agric. Soc. Scot.*, 1916, 28, 92) indicate that spraying with 5 per cent. sulphuric acid once early in July and again in August (the exact time depending on whether the season was late or early) provides an effective

means of controlling bracken. Other weed-killers tried were not of much use. The bracken is not completely eradicated, owing to its underground stems, but it is very much weakened, so that it is prevented from spreading, and growth in subsequent years is considerably reduced. The grass may be slightly scorched at the same time, but is almost completely protected from the spray by the habit of growth of the bracken fronds and soon recovers from any small effects of the acid.

Sulphuric acid spraying appears to be increasing and is likely to be more and more widely used, since for the purpose for which it is best suited, it has important advantages over a number of older weed-killers. The effect is less dependent on the weather than is that of some other sprays, such as copper sulphate; there is no danger of accumulation of toxic compounds in the soil; its effect does not persist in the soil as does that of chlorates; and provided that adequate liming is subsequently carried out it has no harmful residual effect in the soil. It requires, however, the provision and carting of large quantities of water and for the best results, the use of special pressure-spraying equipment.

The acid is usually regarded as corrosive, but if reasonable care is taken to use acid-resisting materials and to wash spraying machinery after use, this causes no difficulty. Sulphuric acid spray has been made up and used by farm workers of all types without accident of any kind being reported. The chief point to remember in making up the diluted acid used for spraying is that the concentrated acid should be added to a much larger volume of water and stirred constantly during mixing. There is then no danger. The diluted acid is destructive to clothes and is painful in cuts and in the eyes, so that it is useful to keep a weak solution of bicarbonate of soda handy for application in case of need.

It is usually recommended to try spraying a small area first, especially where sulphuric acid spraying has not previously been practised, but suitable conditions are now so clearly defined that this procedure is not always necessary.

Other substances

A number of other chemicals have been tried or used on a small scale for weed-killing at various times. Common salt has been widely used, but its action is somewhat uncertain

and variable and is very much dependent on absence of rain. It is liable to have a bad effect on the physical properties of the soil and the presence of any quantity of soluble chloride in the soil is deleterious to the growth of crops. It has to be used in large amounts, but is sometimes useful where the continued barrenness of the soil after its application is not of importance. It is used in Australia in eradication and control of St. John's wort, which is a serious pest on some pasture lands, causing disease and finally death among stock eating it. Crude salt is largely employed to form a barrier round existing infestations of the weed and so to prevent its spread towards adjacent good grazing land. (G. A. Currie, "Report on a Survey of Weed Problems in Australia," *Pamphlet No.* 60, 1936, *C.S.I.R.*, Australia.)

A few trials were made with nickel sulphate during a period following the Great War when copper sulphate was difficult to obtain, but its weed-killing action was less effective than that of copper sulphate and unless there should be a great advantage in price, it is not likely to displace the copper salt.

Sodium and potassium bisulphates have been used locally on a small scale, where they could be obtained cheaply. They are rather unpleasant and difficult to handle and have a somewhat similar effect on weeds to that of sulphuric acid.

Sodium cyanide has been tried but was found to decompose very rapidly in contact with soil and was not considered likely to be of any value as a weed-killer.

Sodium bisulphite has been tried on a small scale recently in New Zealand in the search for a satisfactory non-dangerous substitute for chlorates and preliminary experiments indicate that it may be of use for this purpose. Further comparative trials using sodium bisulphite, potassium bisulphite, ammonium thiocyanate, and sodium chlorate, showed that the bisulphites were, in some circumstances, effective agents for the eradication of ragwort, but the exact conditions for their maximum efficiency cannot yet be laid down.

Owing to the strongly oxidising character of chlorates it has been suggested that other oxidising agents might be efficient as weed-killers and several have been tested. Potassium permanganate was found to be of no value for this purpose, but sodium dichromate, which has also been tried on a fairly extensive experimental scale, is considered to be of

possible value as a weed-killer, although the best conditions for its use have not yet been defined. It is said to decompose in the soil much more rapidly than chlorate, so that it does not continue to affect the soil after application as chlorate does, and it also has not the retarding effect of chlorate on soil processes. It has not the explosive tendency of chlorate, but is very likely to cause fires when in contact with organic matter. It has been stated recently that at least one chemical weed-killer on the market in Canada contains sodium dichromate as the active principle.

In conclusion, it is evident that the control of weeds by means of chemical weed-killers is a practice which may be of considerable value. No one chemical is suitable for all conditions, nor could this be expected. Allowance must also be made for the fact that weed-killers in general are only harmful to weeds already growing; they are, as a rule, without effect on weed seeds, so that any form of chemical treatment is only a temporary measure for weed control. This is, of course, true also of any method of controlling weeds by cultivation. Provided the limitations of the practice are recognised, weed control by chemicals appears likely to be of considerable and increasing value to agriculture.

After the above article was sent to press, there appeared in the *Journal of the Royal Agricultural Society of England*, 1935, **96**, 22-44, an article by H. C. Long and R. K. MacDowall, entitled "Some Chemical Methods of Weed Destruction," which reviews and summarises the developments in the use of certain weed-killers (sulphuric acid, calcium cyanamide, chlorates, and ammonium thiocyanate) during the past two or three years, and also describes and illustrates typical machinery in use for weed-spraying.

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SOME MINOR MINERAL FERTILISER MATERIALS

DURING recent years it has become increasingly evident that the addition to the soil of the three major fertilising constituents, nitrogen, potassium and phosphorus, usually supplied in commercial fertilisers, is not sufficient in all cases to maintain a satisfactory standard of fertility and crop growth. A number of other elements have been found to be of importance, although in many cases the amounts of these subsidiary substances required are extremely small and are usually adequately provided by the soil. Some of them have also probably been supplied in the past as impurities in manures, but with the growing tendency towards purer and more concentrated artificial fertilisers, this source of supply, which was, in any case, purely accidental, is diminishing.

It often happens, however, that some one of these minor elements may be deficient for a special crop on a particular soil, as the requirements of different crop plants for these substances vary widely. This deficiency is liable to become acute in places where the natural reserves of the soil are depleted by the cultivation of the same staple crop over a number of years. An account of the uses, sources, supply and market conditions, primarily with reference to the U.S.A., of a number of these minor fertiliser materials, has recently been published, with an extensive bibliography, by the U.S. Bureau of Mines, as *Information Circular*, No. 6830 (1935).

A large number of elements have been found in plants growing naturally on the soil, but of these only 14, carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, iron, sulphur, manganese, boron, copper and zinc, are believed to be necessary to the growth of normal green plants. The other elements which have been found in plants, including aluminium, arsenic, barium, bromine, chlorine, cobalt, fluorine, iodine, lead, lithium, nickel, rubidium, selenium, silicon, sodium, strontium and titanium, are thought to have been absorbed by chance and to be without significance in plant nutrition.

The minor fertilising materials may be divided into two groups, those which have a direct feeding or stimulating effect on the plant itself and secondly, those which indirectly

produce an effect on the crop by modifying conditions in the soil. These latter substances are often described as soil amendments and as they are used in much larger quantities than the direct-acting minor fertilisers they may be considered first. This group of soil amendments includes three elements, calcium, magnesium and sulphur, of which calcium is by far the most extensively used. Although their chief function is in modifying soil conditions, they are necessary in some cases also as direct plant foods.

Calcium compounds as applied to the soil fall into three categories, the basic group (including the various forms of oxide and carbonate), the gypsum group and those substances such as ground phosphate rock and superphosphate which contain large quantities of calcium compounds, but are used for their phosphate and not for their calcium content. This last group will, therefore, not be considered here.

As indirect fertilisers, calcium compounds of the carbonate or oxide type have several functions. They act as correctives for excessive soil acidity, by providing a base to combine with the soil acids, and are the cheapest and most satisfactory base available for this purpose. They are also said to effect the release of other plant-food materials from insoluble compounds in the soil. They bring about a better tilth by causing the clay particles to flocculate and form aggregates and are said to assist bacterial action in the soil by promoting favourable conditions for the soil bacteria, especially those concerned with the processes of nitrification. Addition of calcium compounds is also believed to be necessary in some cases in order to restore or maintain a correct ratio of calcium to magnesium, since if magnesium is present in excess, it is said to have an adverse effect on the fertility of the soil.

Calcium soil amendments of this type are applied to the soil in a number of forms—as limestone, dolomite, calcareous marl, oyster shells, quick-lime, air-slaked lime and hydrated lime. There are no rigid specifications for agricultural limestone, it may range from a high-calcium stone, with 98 per cent. $CaCO_3$, to a dolomite, with 54 per cent. $CaCO_3$ and 44 per cent. $MgCO_3$. It must be ground before use and the general standard of fineness appears to be that the whole of the material must pass a 10-mesh sieve. A good deal of the ground product would, of course, be much finer.

In view of the fact that on calcination limestone is converted into the oxide, quick-lime, with the loss of all the carbon dioxide originally present, a smaller quantity (about half by weight) of quick-lime is required to produce the same effect as limestone, but calcination adds to the cost. Quick-lime is unpleasant to handle and to distribute in the field, but it requires no grinding. It does not keep well, as on exposure to the air it absorbs carbon dioxide and moisture and, ultimately, is reconverted into calcium carbonate.

In recent years, hydrated lime, or calcium hydroxide, has come into prominence. It is a fine, dry, powdery product, easier to handle than quick-lime, and keeps much better. The production and sale of hydrated lime has shown remarkable advances during recent years.

The proportions of quicklime, hydrated lime and limestone required to supply the same amount of base to the soil may be regarded as being roughly in the proportions 2 : 3 : 4. The final effect in the soil appears to be the same, although in some cases quick-lime produces a more pronounced immediate response than limestone.

Calcareous marls are usually unconsolidated limestone deposits containing varying proportions of clay and sand and the calcium carbonate content may range from 5 to 95 per cent. of the whole material. Although useful locally, they are in general not sufficiently valuable to be worth transporting to any distance. Special forms of calcium carbonate, such as oyster and other shells, are also only of local interest and the same is often true of other forms of lime obtained as by-products in manufacturing processes.

Agricultural gypsum, or land plaster as it is sometimes called, consists of the more or less pure mineral gypsum, hydrated calcium sulphate, $CaSO_4.2H_2O$. The mineral as mined is dried if necessary, but not calcined, and is ground to a fine powder.

Gypsum serves to supply the soil with both calcium and sulphur in the form of sulphate, but has, of course, no neutralising effect on soil acidity. It has been found of value as a direct fertiliser for some specific crops, such as alfalfa (lucerne) and ground-nuts, which are liable to suffer from sulphur deficiency. It is said to have an indirect effect by helping to retain ammonia in farmyard manure and to have a

beneficial effect on soil bacteria. One of its important uses is in the reclamation of land suffering from "black alkali" (sodium carbonate), which is inimical to all forms of plant life. On the addition of gypsum to a "black alkali" soil, an exchange reaction takes place, with the formation of calcium carbonate and sodium sulphate, which can be comparatively readily leached out of the soil and is, in any case, less harmful than sodium carbonate.

The mineral anhydrite, which consists of anhydrous calcium sulphate, is sometimes used as a substitute for gypsum, but owing to its lower solubility, it must be more finely ground than gypsum in order to produce the same effect.

Gypsum occurs as a constituent of superphosphate and the extensive use of the latter probably helps in many instances to protect crops from sulphur deficiency.

Magnesium compounds may act in the soil as direct and as indirect fertilisers. When applied to the soil as the carbonate as is the case with all limestones and dolomites containing more or less magnesium, the magnesium carbonate acts in a similar manner to calcium carbonate. It helps to neutralise soil acidity, to promote flocculation of the clay and to assist bacterial action. It may also happen, in a few cases, that crops growing on soils deficient in available magnesium compounds suffer from an actual deficiency of magnesium as a plant food and in these cases the magnesium required may be supplied either in the form of a magnesian limestone or dolomite, as water-soluble magnesium sulphate (Epsom salts), or as a constituent of certain potash fertilisers such as kainit, which contain magnesium sulphate. The more readily soluble compounds of magnesium such as the sulphate, alone or in conjunction with potash salts, are said to be more effective in combating actual magnesium deficiencies than the carbonate compounds. Certain crops, such as tobacco, appear to be especially liable to diseases due to magnesium deficiency. It has recently been shown in Germany (*Arbeiten über Kalidungung*, Band II, by O. Eckstein, Berlin, 1935) that symptoms of magnesium deficiency seem to be especially liable to occur on the lighter types of soil. This is in accordance with previous work on a magnesium deficiency disease of tobacco in America, where the disease was found to be correlated not only with lack of available magnesium,

but also with a sandy type of soil and with the seasonal rainfall.

The recent work in Germany has also demonstrated that, although the actual magnesium requirement of most plants is low in amount, even a very slight fall below the minimum necessary for satisfactory growth is sufficient to cause a serious reduction in crop yield.

Sulphur and its compounds may act both as direct and as indirect fertilisers, but the chief use of the element is as a direct plant nutrient. Soils are not, in general, deficient in sulphur compounds and comparatively large amounts are added in commercial fertilisers, such as superphosphate (containing gypsum), ammonium sulphate and potassium sulphate. Occasionally soils are found to be deficient in sulphur and this deficiency may cause either poor general growth, or specific disease, such as the "yellows" disease of tea which has caused great trouble and difficulty in establishing successful tea-gardens in parts of Nyasaland and has recently been shown to be due to lack of sulphur in the soil. Sulphur deficiency may usually be corrected by the application of either elementary sulphur or of sulphates.

As an indirect fertiliser, or soil amendment, elementary sulphur is employed, in addition to calcium sulphate, considered above. Its action is believed to be due primarily to small amounts of free sulphuric acid formed from it by oxidation. Only the very finely powdered forms of sulphur are regarded as suitable for direct application to the soil and the fineness may vary from 50 to 99 per cent. passing 200-mesh to 99 per cent. passing 300-mesh. Activating agents are sometimes added, in order to hasten the oxidation of the sulphur and so produce quicker results.

The application of elementary sulphur is said to increase the acidity of the soil and a similar effect is produced by the use of ferrous sulphate or a mixture of ferrous and ammonium sulphates. This mixture is employed on certain types of grass sward, such as golf greens, as it is believed that by increasing the acidity of the soil, it encourages the growth of the finer species of grasses, which are desirable to form a firm smooth turf.

The use of excessive amounts of elementary sulphur may cause toxicity in the soil, possibly by making the soil too

acid or by incomplete oxidation resulting in the formation of toxic compounds. It has recently been suggested that in parts of Trinidad, large quantities of gypsum, naturally present in the soil, may exert a deleterious effect on cacao trees.

Iron compounds have long been recognised as essential to the normal growth of green plants. Iron is an integral element in the formation of chlorophyll, the green colouring matter of plants, and its absence gives rise to a pathological chlorosis of the plants. The amounts needed are small and in nearly all cases are supplied by the iron compounds present in the soil.

It occasionally happens that crops, particularly certain species, suffer from iron deficiency, either on account of actual shortage of iron in the soil, or because the iron present is rendered unavailable to the plant by the presence of an excess of manganese or lime. Ferrous sulphate is the compound most usually employed to overcome iron deficiency.

A striking example of the effect of manganese in causing iron deficiency occurs in many of the pineapple soils of Hawaii and the most effective treatment has been found to be the spraying of the crop with a dilute solution (25 lb. to 50 galls. of water) of ferrous sulphate, applied at the rate of 20 galls. per acre at each spraying. The treatment has to be repeated at intervals, especially during periods of rapid growth. Chlorosis due to iron deficiency may also be induced by the presence of a large excess of lime and in this case, it appears to be more efficacious as a rule to apply the ferrous sulphate to the soil.

Manganese is regarded as one of the elements essential to plant growth, but the amount needed is very small and where quantities in excess of this are present, toxicity to the plant results. Few soils are known to be naturally deficient in available manganese, but an excess of lime, either normally present in the soil or added by over-application of lime-bearing materials, may have an inhibitory effect on the absorption of manganese by the crop, which then suffers from manganese deficiency. An instance of this kind occurs in the calcareous soils of the Everglades district of Florida. Manganese has been found to be a limiting factor in this case, particularly with the tomato crop. The trouble has been cured by the application of small amounts of manganese sulphate, mixed with

commercial fertiliser, at the rate of from 50 to 100 lb. per acre. Manganese sulphate has given the best results as a source of available manganese to the plant and is the only salt used on a commercial scale.

Copper in minute amounts appears to be essential to plants. The quantities needed are present in most soils and an excess has a toxic effect on crops. Copper deficiency may show itself either by failure of the crop to grow satisfactorily or by specific physiologic diseases, such as "die-back" of citrus trees.

Copper sulphate is the principal compound used for supplying copper to soils. It may be used either alone or mixed with commercial fertiliser at the rate of from 30 to 50 lb. per acre. In treating citrus trees which are suffering from copper deficiency, it has been found advantageous to apply small quantities of copper sulphate (from ¼ to 1 lb. per tree) by spreading it on the soil round the tree, the amount used depending on the size and age of the tree.

Zinc compounds are used on a very small scale as direct plant nutrients. Only minute amounts of zinc are needed for crop growth, the amount varying with different species of plants, and these quantities are usually present in the soil. On some soils and with certain crops, however, zinc-deficiency diseases may occur and these can be corrected, either partially or completely, by the addition of zinc salts. The diseases are of the physiologic type, such as "rosette" of pecans, "mottle-leaf" of citrus trees, and "bronzing" of tung trees (cf. this BULLETIN, 1935, **33**, 468).

Zinc sulphate is usually employed to combat zinc deficiency and may be applied in several ways: by applying directly to the soil, by injection of a solution into the tree trunk, by placing the solid salt in a hole bored in the trunk, or by spraying a solution on the trees. The strength of solution used for spraying must be carefully controlled, as if it is too strong, it may cause severe foliage injury. The risk of this injury can be reduced in some cases by adding hydrated lime to the zinc sulphate solution.

The quantities of zinc used must be regulated with extreme care, as even a small amount in excess of that required is liable to cause poisoning of the plants.

It will be seen that the whole question of supply of

subsidiary elements to plants is extremely complicated and in many cases compounds which are essential in minute amounts rapidly become toxic when these amounts are exceeded. Often the presence of a large quantity of one essential element exerts an inhibitory effect on the absorption of another element, which may be present, but is rendered unavailable to the plant. The inter-relationships of these subsidiary elements and their effects on crops cannot be regarded as finally settled.

A comprehensive review of plant diseases associated with the deficiency of various elements in the soil was published by the Imperial Bureau of Soil Science as *Technical Communication*, No. 31 (1934). This includes lists of the crops affected by a deficiency of one or more specific elements, descriptions of the symptoms observed and methods of treatment practised, with a very large number of references to original literature.

NOTES

The Exhibition Galleries.—A feature of the Exhibition Galleries is the illuminated picture models (dioramas) which are used to illustrate the scenery and the various industrial operations in the countries of the Empire.

There are now more than one hundred of these attractive models distributed through the various Courts of the Public Exhibition Galleries and they provide an unfailing source of interest to visitors. Eight dioramas were lent from the Galleries for use in the Government Pavilion at the International Exhibition, which was held last year at Brussels, where they attracted considerable attention.

Amongst the most recent additions is a view of the Port of Haifa, Palestine, as seen from Mount Carmel, which is reproduced in Plate I. The descriptive label attached to the model reads as follows :—

> "Haifa, situated at the southern end of the Bay of Acre, is the headquarters of the Northern District of Palestine, as well as the principal port. It shares with Jaffa (to the south) the bulk of the trade of the country; it is the focal point of 'big business' in Palestine, and is fast becoming the chief commercial centre of of the Eastern Mediterranean.
>
> "From our viewpoint on Mount Carmel, which dominates the town, and where once dwelt the Prophet Elijah, a wide prospect rich in historical fame is obtained. Immediately below lies the town itself, its placid appearance in the evening sun giving little evidence of the bustling activities of its 60,000 inhabitants

or of its prosperous manufacturing industries ranging from Portland cement to oil, soap and cigarettes. Beyond are the harbour and docks, only completed in 1934, yet already the port of call of many steamship lines.

"Further distant are the wide expanses of the fertile Plain of Esdraelon, fringed by 12 miles of golden sands and traversed by the slow-flowing Kichon and to the north, by the Na'amein, on whose banks the Phoenicians first learned to manufacture glass. At the farthest limit of the Bay of Acre is the ancient town of Acre, famous in Crusading history; while along the horizon lie the mountains of Syria."

The funds for this diorama were provided by the Palestine Government and the construction of the model was carried out in the Imperial Institute Studio.

Other outstanding additions to the Galleries during the past quarter include the following exhibits.

To the Indian Court has been added a display, collected with the assistance of the Indian Jute Mills' Association and the Dundee Chamber of Commerce, illustrating the story of jute from the natural stems to the ubiquitous sack for the transport of cement, sugar, coal, grain, etc. Another exhibit, obtained through the kind offices of Messrs. Thomas Duff, Ltd., shows how linoleum is built up from a number of raw materials, such as ground cork, wood-flour, linseed oil, jute, rosin and gum, most of which are of Indian or other Empire origin.

In the new Mysore Court which has been installed during the period, with the assistance of the Mysore Government and the Trade Commissioner for Mysore, the visitor can trace back the history of a beautiful silk fabric, through the reeled silk in the filature, to the cocoon, the silk-worm, the egg, and the male and female moths. In a similar way the story of sandalwood is told from the tree to the valuable sandalwood oil and some of its applications.

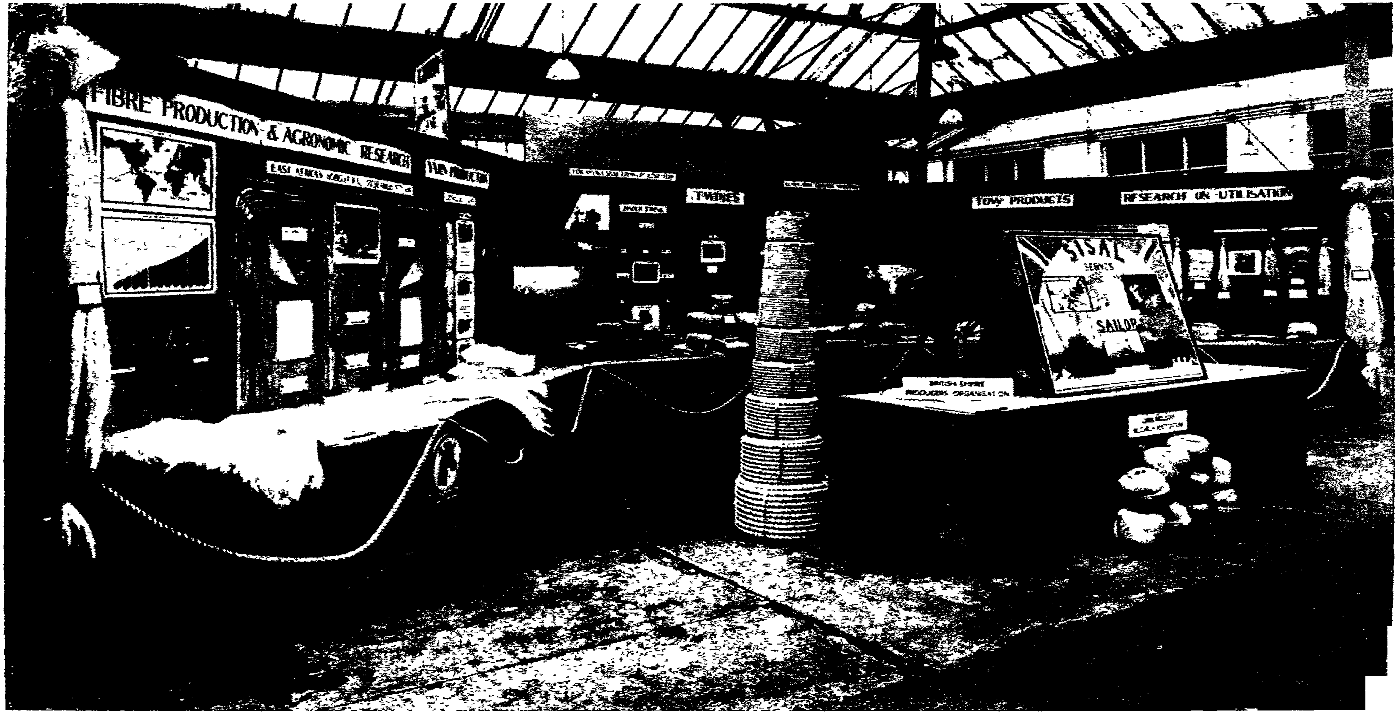
In the Australian Court is now displayed the fine collection of photographs of scenes and life in New South Wales which created so much interest when shown at Grosvenor House, Park Lane, last year. Not only has the complete collection been presented to the Institute but funds for the suitable framing of the pictures and for the provision of an appropriate screen fitting have been generously supplied by the Sun Newspapers Ltd. (Sydney).

To the West African Court has been added an exhibit, collected with the assistance of the British Oil & Cake Mills, Ltd., tracing out the numerous uses of the West African oil palm both in West Africa itself and in modern industry, while in the South African Court can now be seen one of the latest developments in the use of asbestos, in the form of a modern fire-fighting suit made of that material, kindly furnished by Messrs. Siebe Gorman & Co., Ltd.

PLATE I

THE PORT OF HAIFA PALESTINE
Reproduced from a Diorama in the Exhibition Galleries of the Imperial Institute

PLATE II



Imperial Institute Exhibition of Commercial Plant Fibres.
The Sisal Exhibit.

Empire Fibres Exhibition.—An Exhibition of Commercial Plant Fibres other than cotton was held in the Exhibition Pavilion of the Imperial Institute from March 26 to April 9, 1936. In the unavoidable absence, owing to illness, of Captain Euan Wallace, M.P., Secretary of the Department of Overseas Trade, the Exhibition was opened by Mr. Patrick Munro, M.P., Parliamentary Private Secretary to Captain Wallace. Sir Harry Lindsay, Director of the Imperial Institute, presided. At a luncheon, arranged by the British Empire Producers' Organisation, Major Sir Humphrey Leggett referred to the co-operation which now existed between those who produced and those who marketed fibre products.

The aim of the Exhibition, which had been organised by the Imperial Institute with the co-operation of the Advisory Committee on Vegetable Fibres of the Institute under the Chairmanship of Mr. Alfred Wigglesworth, was to illustrate the resources of Empire countries in plant fibres used in the manufacture of textiles, ropes, cordage, twine, brush-making, upholstery and other purposes; and in particular to link by means of those exhibits the work of the overseas Empire producer with that of the United Kingdom manufacturer. In organising the display the Director of the Imperial Institute had obtained the co-operation of leading official, commercial and scientific authorities concerned with the different classes of Empire fibres and the Exhibition comprised the following sections: Phormium or New Zealand hemp (the High Commissioner for New Zealand); Jute, Sunn Hemp, Coir and Palmyra (the High Commissioner for India); Flax and Linen (the Linen Industry Research Association); Sisal from East Africa, Phormium from St. Helena (the Hard Fibres Section of the British Empire Producers' Organisation); Mauritius Hemp (Sir Louis and Captain Souchon); Ceylon Coir and Kitul (Messrs. J. H. Vavasseur & Co., Ltd.); Sierra Leone Piassava (Messrs. James Clark); Sierra Leone Raffia (Messrs. Wigglesworth & Co., Ltd.); and also exhibits illustrating investigations carried out at the Imperial Institute on Empire fibres for marine cordage and on Sierra Leone piassava. The Director, Royal Botanic Gardens, Kew, had kindly furnished living plants for several of the exhibits.

The selection and arrangement of the exhibits in each section was planned with the object of rendering the exhibits of interest alike to the Colonial Officer, the commercial man, the scientist and to the student. The plan adopted was to illustrate, by means of samples and photographs, the complete story of the different fibres from the living plant to articles manufactured from the raw material. So far as possible each Section was in charge of an expert officer able to answer commercial and other enquiries relating to his exhibit. A

printed Guide to the Exhibition had been prepared and comprised a brochure of 40 pages, including, in addition to a Foreword by the Director of the Imperial Institute, a descriptive account of the fibres exhibited, classified as stem fibres, leaf fibres and fibres from fruits and seeds, introduced by a survey of plant fibres and followed by a catalogue of the exhibits and an account of investigations at the Imperial Institute. Copies of the Guide are obtainable from the Imperial Institute, price 3*d*. An indication of the general scheme of arrangement is afforded by the accompanying photograph (Plate II) illustrating the Sisal exhibit arranged by the British Empire Producers' Organisation in co-operation with the Sisal Research Board.

Imperial Institute Cinema.—For many years the Cinema of the Institute has been looked upon as a centre in which the general public, particularly school children, can see displays of Empire films. Hitherto these films have been of the "Silent" type, but with the replacement of the silent projectors by modern equipment it is now possible to provide attractive programmes of up-to-date "Talkie" films. These programmes include productions of the General Post Office Film Unit, together with films loaned by Governments of the Dominions, India and the Colonies.

The Cinema will continue to cater for educational visits paid by school parties and seats are reserved without charge on prior application. There are four shows on weekdays, 10.15, 11.35, 2.15 and 3.35—each lasting about one hour and two on Sundays at 2.45 and 4.15.

A monthly programme is printed and copies will be posted on request.

Co-operation with British Film Institute.—The Imperial Institute's film activities, which started in the early days of the late Empire Marketing Board and were financed by the Board, have played no small part in the conversion of educationists to the use of the Cinema as a means of visual instruction and in encouraging the production of educational films, particularly those which depict life, scenery and industries in all parts of the Empire.

The Commission on Cultural Films of some years ago, out of which the present British Film Institute has grown, made much use of the information which the Imperial Institute was able to give out of its experience and contact on film questions with schools and educational authorities.

It is only natural, therefore, that the Imperial Institute should continue to keep in close touch with the British Film Institute in its present work. The Director, as a member of

the Dominions, India and Colonial Panel of that body, is able to contribute, from his experience of Empire films, towards the solution of questions vital to the Panel and especially questions of policy affecting the cultural and educational cinematograph activities of overseas countries of the British Empire.

The setting up by the British Film Institute of a National Film Library—a national repository of films of permanent value—has received universal approval and agreement with the British Film Institute has been reached whereby their activities and those of the Empire Film Library are clearly defined and uneconomic competition and overlapping are avoided in their respective spheres.

Colonial Visitors.—The following is a list of officers on home leave from the Colonies who have visited the Institute during the past quarter.

FEBRUARY

F. W. Aston, Veterinary Officer, Kenya.
C. T. Cogle, Chief Inspector of Mines, Kenya.
Captain G. S. Greene, Provincial Forest Officer, Gold Coast.
E Innes-Nisbett, Agricultural Officer, Sierra Leone.
G. D. P. Olds, Agricultural Officer, Straits Settlements and F.M.S.
G. N. Sale, Conservator of Forests, Palestine.
R. B. Shorter, Agricultural Officer, Nigeria.
J. Steele, M.C., Agricultural Officer, Gold Coast.
R. G. R. Townsend, Assistant Conservator of Forests, Nyasaland.
E. W. Wright, Inspector of Mines, Nigeria.

MARCH

G. W. G. Briggs, Agricultural Officer, Nigeria.
E. Harrison, C.M.G., Director of Agriculture, Tanganyika.
B. G. Owen, Agricultural Officer, Nigeria.
C. F. M. Swynnerton, Director of Tsetse Research, Tanganyika.
A. A. Wright, Secretary for Native Affairs, Fiji.

APRIL

A. W. Cardinall, Commissioner, Cayman Islands.
B. E. Crawfurd, District Officer, British Solomon Islands.
A. F. Grimble, C.M.G., Governor and Commander-in-Chief, Seychelles.
E. G. Hawkesworth, M.C., District Officer, Nigeria.
P. S. Laws, Senior Assistant-Conservator of Forests, Nigeria.
E. F. Peck, Veterinary and Agricultural Officer, British Somaliland.
B. R. Wood, Conservator of Forests, British Guiana.
F. Young, Education Officer, Kenya.

All Dominion and Colonial officers who may be visiting London are invited to come to the Institute to see our Galleries or to discuss scientific and technical problems in which they are interested.

Sisal in Salvador.—According to the Department of Overseas Trade Report, No. 631 (of 1936) on "Economic Conditions in the Republic of El Salvador," in 1934 there were

3,558 hectares under sisal hemp (henequen) in that country, the production of fibre being 59,147 quintals (2,720 tons). The whole of the production is now used in making bags for coffee and sugar. There are two bag-making factories, one of which holds a monopoly concession at present. Some 800,000 bags for coffee, more than sufficient for the whole coffee export, and 250,000 bags for sugar are being produced. To favour certain local merchant interests the duty on imported jute bags was reduced in August 1935, but in October 1935 a duty of 10 U.S. cents was placed on each exported bag made of foreign material, a delay until May 1936 being allowed for liquidation of present stocks. In 1934 imports of jute bags for coffee, which come mainly from Czechoslovakia and to a less extent from Germany, had already fallen to one-tenth of the quantity of 1932. In the case of sugar bags, however, which come mainly from the United Kingdom, there was only a slight drop in the imports, as the locally-made sisal bag has not proved as suitable for sugar.

Tung Oil in China.—The improvement in China's tung oil trade and the need for further development are discussed in a recent issue of the *Chinese Economic Journal and Bulletin* (1936, Vol. XVIII, No. 2, February, pp. 145-151). The exports of tung oil from China during the first nine months of last year totalled 576,987 quintals, an amount which represented an increase of 7·4 per cent. over that shipped during the corresponding period in 1934. The present prosperity of the industry is ascribed to the following causes: (1) The United States, the largest market for Chinese tung oil, has shown an increased demand, due to a steady revival of business in the various chemical industries. (2) European countries since the outbreak of Italo-Ethiopian hostilities have been actively buying supplies in preparation for a possible emergency. (3) Chinese tung oil is largely produced in the inner provinces from which, owing to insufficient transportation facilities, goods are not easily brought out. At the centres of distribution, storage equipment is likewise inadequate. Consequently, when foreign orders increase, there is always a shortage of immediate supply and as a natural consequence those who have stocks in hand will not sell unless attractive prices are offered. (4) The price of tung oil has increased as a result of the rising tendency of prices in China.

It is evident that the present prosperity of China's tung oil trade is the result of factors quite beyond the control of Chinese producers and merchants and is due to an abnormal boom and not to a regular development of markets.

In order to ensure a permanent market the necessity is

emphasised of seeking real improvement in the Chinese methods of production and marketing. The serious defects now prevailing in these methods are enumerated and the following recommendations are made with a view to bringing about the desired improvement. The centralisation of plantations is considered to be the most urgent and for this purpose a selection should be made of localities with a suitable climate and soil for tung trees and in them large-scale cultivation should be started through Government encouragement and farmers' organisations. By this means the production of tung oil would be increased. The present antiquated methods of preparing the oil should be replaced by modern ones in order to minimise the waste of oil. Attention should also be directed to the refining and grading of the oil since its reputation and marketability depend largely on the maintenance of an accepted standard which in the past was impossible as a result of adulteration.

In regard to transportation, economy and convenience are the two guiding principles, though methods of packing also need improvement. Government assistance to inland waterway transportation is indispensable in this connection and Government transportation services should not only reduce freights but assume responsibility for the safe conveyance of goods. Steps must be taken to effect a strong organisation among dealers so that by co-operative bargaining more favourable terms might be obtained from shipping firms in regard to ocean freights. As to marketing, efforts should be made to establish direct contact with foreign consumers and thereby eliminate the increased costs resulting from the heavy commissions paid to middlemen.

The article from which the above abstract has been made concludes with the opinion that China's success in establishing a predominant position on foreign markets in respect of tung oil will in the long run depend entirely upon the amount of effort the country itself makes for the extension of her trade in this article.

Mining Royalties and Rents in the British Empire.—In continuation of its policy of bringing to the notice of the public facts and figures relating to the mining industry of the Empire by means of a series of brochures, the Imperial Institute has just issued an up-to-date and authoritative work on "Mining Royalties and Rents in the British Empire" (183 pp., price 3*s.* 6*d.*, postage 5*d.*). This new work has been prepared by the Mineral Resources Department of the Institute, with the co-operation of over 70 members of overseas mining departments and some hundreds of companies working mineral deposits in the United Kingdom.

The amount and method of assessment of royalties are regarded as matters of considerable importance in the development and prosperity of a mining industry. The extent of these royalty charges may be illustrated by the fact that coal in Great Britain pays nearly £5,000,000 per annum; in the Federated Malay States, tin pays nearly £1,000,000, whereas in the Union of South Africa the profits tax, excess profits duty, etc., on the gold industry produced over £13,000,000 in the year 1934-35.

Following an introduction dealing briefly with royalty systems in general, the main subject matter is divided into two parts. In Part 1 (132 pp.) the statement for each country opens with a summary as regards the ownership and right to work minerals (whether vested in the Government or in private persons) and in this connection attention may be drawn to the useful statement regarding the rather complex conditions prevailing in the Union of South Africa. Next follow details of royalties and export duties leviable on minerals and metals and the period, terms of renewal and "dead" or sub-surface rents of mining leases.

In Part 2 (29 pp.) the royalties and export duties detailed in Part 1 have been summarised, for reference purposes, under nine groups, i.e. coal; petroleum; natural gas; bituminous and oil shales; ores of iron and of the ferro-alloy metals; base metals; precious metals; precious stones; and miscellaneous minerals.

Production of Industrial Minerals in the Union of South Africa.—The following summary regarding mineral production has been based on information supplied by the Department of Mines, Pretoria, Union of South Africa.

Antimony.—The Morning Mist antimony mine in the Barberton district, Transvaal, produced about 13 tons of ore averaging 37 per cent. stibnite during the first quarter of 1935, but production has since ceased. There was no production recorded for 1934.

Stibnite and its oxidation products occur associated with gold in the northern line of reefs of the Murchison Range in the Pietersburg district of the Transvaal. The reefs, which occur in lenticular masses up to 20 ft. wide, have been traced intermittently for 30 miles. The ores contain from 4 to 60 per cent. of stibnite associated with gold.

Development on a fairly extensive scale has been proceeding in this area for the past two years and a pilot plant is being erected by one of the companies concerned. The high-grade antimony ore will probably be sorted and exported as such in the first instance, the lower grade ore being treated for the

extraction of its gold. Recovery of antimony at the mines from these ores will receive consideration later.

Arsenic.—A small plant for the production of white arsenic recently installed at the Bonanza gold mine, Barberton, is estimated to be capable of handling 30 tons of concentrates per month.

The New Consort Gold Mines Ltd., Barberton district, have ceased to produce white arsenic owing to alterations in the surface layout of the plant. It is estimated that approximately 35 tons of arsenic per month could be produced from the arsenical gold concentrates now being roasted in Brunton and Skinner furnaces.

Beryl.—Interest has been taken recently in the occurrence in Namaqualand of beryl suitable for chemical and metallurgical purposes, the output during 1934 and 1935 being estimated at about 80 tons. During 1935, about 20 tons of the mineral, containing about 12·3 per cent. BeO and valued at £140 were exported.

Bismuth.—Deposits of bismuth ore occur in Namaqualand and active prospecting has been in progress recently. During 1935, 12 cwts. of bismuth ore were exported. No production or sales of this mineral were reported for 1934.

Copper.—The Messina Development Co. produces copper ingots assaying 99·88 per cent. of metallic copper and free from such impurities as lead, zinc and arsenic.

The Transvaal Consolidated Mines Ltd. and the Transvaal Gold Mining Estates Ltd. produce copper concentrates which contain gold and silver and are sent overseas for treatment.

The production of ingot copper and concentrates during 1934 and 1935 was as follows :—

	1934. *tons.*	1935. *tons.*
Copper ingots . . .	7,659	10,331
Copper concentrates . .	538	1,119

All of the concentrates produced in 1935 were exported to the United States. Of the 8,417 tons of copper ingots exported, 8,063 tons were sent to the United Kingdom.

Chrome ore.—The Union possesses large deposits of chrome ore which are cheap to mine and are being exploited in the Rustenburg and Lydenburg districts. Demand for these ores has shown considerable increase and production has been expanded accordingly.

Messrs. Chrome Corporation (S.A.) Ltd. supply two grades of ore :

Friable ore.—Average assay, 44 to 45 per cent. Cr_2O_3 ; 3 per cent. SiO_2.

Hard lumpy ore.—Average assay, 44 to 45 per cent. Cr_2O_3 ; $3\frac{1}{2}$ per cent. SiO_2.

Messrs. African Mining & Trust Co. (Pty.) Ltd. supply the following five grades of chrome ores: *friable ore*, grade A, grade A washed, grade B, grade B washed; *hard and lumpy ore*, grade C.

Typical analyses of four of the grades shipped are as follows:

		Friable Ore			Hard Lumpy Ore
		Grade A.	Grade A. Washed.	Grade B.	Grade C.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Silica	SiO_2	4·85	1·81	2·08	3·40
Chromic oxide	Cr_2O_3	48·38	49·55	47·60	45·80
Ferrous oxide	FeO	24·98	21·75	23·76	28·01
Alumina	Al_2O_3	10·20	13·95	16·54	11·14
Magnesia	MgO	11·35	12·65	9·54	11·95
Lime	CaO	0·09	—	0·46	—
Manganese	Mn	—	—	0·02	—

The composition of grade B washed is the same as that of grade B but a higher minimum chromic oxide content can be guaranteed.

In 1935, the production of chrome ore amounted to 88,229 tons as compared with 59,499 tons in 1934. In addition, there was an output of 774 tons of concentrates, a decrease of 115 tons compared with 1934. The ores and concentrates carried about 44·2 and 47·4 per cent. of chromic oxide, Cr_2O_3, respectively.

The sales of chrome ore during 1935 totalled 67,473 tons, an increase of 23,421 tons over those for 1934. Sales of chrome concentrates also increased from 508 tons to 835 tons.

The quantity exported during 1935 was 99,072 tons, i.e., more than double that sent overseas during 1934. The principal importing country in 1935 was Germany (49,139 tons), closely followed by the United States (45,581 tons), while Great Britain was third (3,839 tons).

Iron ore.—It has been proved that the Union of South Africa is richly endowed with iron ores which rank in quality and quantity with those of the most favoured countries of the world.

Production of iron and steel commenced early in 1934 with the smelting operations of the South African Iron and Steel Industrial Corporation Ltd., which body has fully developed two mines in the Transvaal to meet its own requirements.

The output from the Thabazimbi mine during the three months October to December 1935 amounted to 73,652 tons, containing 66·5 per cent. of iron. The Pretoria Townlands deposit during the same period yielded 15,932 tons, averaging 49·3 per cent. iron. The total production of iron ore in the Union, during 1935, amounted to 299,247 tons as compared with 229,494 tons in 1934.

Iron pyrites.—The only output of pyrites results from the concentration of auriferous ores of the West Rand Consolidated Mines Ltd., Krugersdorp. These are sold to the local explosives industry for use in sulphuric acid plants. Sales and shipments during 1935 amounted to 24,672 tons as compared with 15,518 tons in 1934. On the average, the pyrites produced contained about 45 per cent. of sulphur.

Lead ore.—In the past the production in the Union of this ore has been small and mostly obtained from the Marico district of the Transvaal.

Early in the year attention was directed to the Edendale lead mine near Pretoria and to the Moor Hill silver-lead mine near Waterval Onder station in the Eastern Transvaal. The production of lead-ore concentrates in the Union during 1935 amounted to 6 tons as compared with 92 tons in 1934 (*see also* p. 240).

Manganese.—With the exception of a small tonnage of friable ore with a high manganese dioxide content which is mined for use in local industries in the Krugersdorp district, Transvaal, the production comes from the Postmasburg deposits in the Cape Province.

The character of the Postmasburg deposits is such that the varying requirements of consumers in respect of manganese, iron and silica content in consignments can be met, phosphorus remaining consistently low at less than 0·1 per cent.

The three main grades of ore available for shipping have the following approximate percentage composition:—*high grade*, manganese, 50, iron, 7 to 9; *medium grade*, manganese, 46 to 48, iron, 11 to 14; *low grade*, manganese, 43 to 45, iron, 13 to 17.

Silica is consistently below 6 per cent., but can be increased if required. Phosphorus is guaranteed at less than 0·1 per cent., but shipments over the past six years have shown consistently lower amounts.

The production of 30,610 tons of ore during the last quarter of 1935 showed a substantial increase over that of the preceding quarter, which amounted to 19,730 tons. This was due to development work having been speeded up on certain sections of the deposits (hitherto unworked) in anticipation of the completion of railway extensions then in progress and expected to be ready towards the end of April 1936.

Exports show only a small increase during the quarter, the policy of both producers being to postpone any considerable increase pending provision of increased railway facilities.

The demand for these ores has been insistent and large forward orders having been booked to the end of 1936, the 1935 exports of 80,213 tons should be more than doubled.

The tonnages consigned, in 1935, to the principal importing countries were as follows: Holland (27,790), Belgium (14,477), France (12,436), Germany (8,079), Canada (5,217) and Great Britain (5,103).

Nickel.—So far, no nickel ores have been produced in the Union, although deposits of what may be considered potentially large tonnages of ore have been known for many years. Deposits which have received most attention are those in the neighbourhood of the Rustenburg platinum mine, west of Rustenburg; in East Griqualand; and at Insizwa and Tabankulu in Pondoland.

Prospecting and development work on the Rustenburg deposits is still in progress; and a recent preliminary geophysical survey carried out by the Union's Geological Survey over a small area on the property of the South African Minerals Ltd., gave results warranting more extensive investigation on these lines.

Platinum.—The Rustenburg Platinum Mines Ltd. remains the only producer in the outside districts. It is reported that the oxidised zone at this mine is now becoming exhausted, so that it will be necessary to turn, more and more, to the working the sulphide ore. Platinum, palladium, iridium, ruthenium and gold are recovered, the output of the platinum group metals for the last three months of 1935 being 7,687 oz. while sales totalled 7,015 oz. The output for the year at 31,272 oz. was 6,739 oz. below that of 1934. Sales, however, totalled 31,338 oz. as compared with 22,889 oz. for 1934.

Tin.—The principal deposits are situated in the Transvaal and occur in, or in association with, the Red Granite of the Bushveld Complex and in the felsites and sedimentary rocks of the Rooiberg Series forming the roof of the Complex.

A small recovery of alluvial concentrates at Kuils River in the Stellenbosch district of the Cape Province continues, the concentrates being sent overseas for smelting.

The output for 1935 amounted to 912 tons of concentrates estimated to contain 615 tons of the metal. The tin ore exported went principally to the Straits Settlements (581 tons), Italy (214 tons) and United Kingdom (153 tons).

Tantalum.—Concentrates containing tantalite and columbite are being recovered from weathered pegmatites north of the Ellerton Consolidated gold mine, in the Pietersburg district. Most of the ore is obtained from shallow trenches over a small area. Recently, other discoveries have been reported in this area.

Three analyses made for the Mines Department by the Government Chemical Services showed samples to have the following percentage composition:—

			A.	B.	C.
Tantalic oxide	Ta_2O_5	.	31·1	46·4	47·8
Niobic oxide	Nb_2O_5	.	35·0	27·5	29·5
Tungstic oxide	WO_3	.	0·44	0·75	0·40
Titanium dioxide	TiO_2	.	6·40	0·37	0·28
Tin oxide	SnO_2	.	trace	trace	trace
Ferrous oxide	FeO	.	21·55	15·71	13·80
Manganous oxide	MnO	.	2·95	3 52	4·03
Silica	SiO_2	.	3·88	5·60	4·98
Total		.	101·32	99·85	100·79

A *Composite sample of material for export*
B *Tantalite crystals from trenches in weathered pegmatites and schists.*
C *Tantalite crystals from fresh pegmatites exposed by winning.*

The production during the last quarter of 1935 was 2·6 tons of ore containing about 70 per cent. of oxides of tantalum and niobium. The output for 1935 amounted to 8·1 tons. No production was recorded for 1934.

Tungsten.—Small quantities of scheelite concentrates are being produced from the recently discovered deposits near Xamchap on the Orange River, Namaqualand; and from the Gordonia Division, Cape Province.

The output of scheelite for 1935, most of which was produced during the last quarter of the year, amounted to 8 tons of ore and contained 66 to 70 per cent. of tungsten.

Asbestos.—The output of asbestos during 1935 as compared with 1934 was as follows:—

	Production. *tons.*		Sales. *tons.*	
	1934.	1935.	1934.	1935.
Amosite	2,552	4,031	3,354	4,182
Blue asbestos	2,413	2,097	2,511	2,211
Chrysotile	11,185	12,105	9,844	13,946

The quantity of raw, crude and waste asbestos exported during 1935 amounted to 21,169 tons valued at £307,182 as compared with 15,565 tons valued at £255,611 for 1934. The principal importers during 1935, by tonnages, were the United Kingdom (10,968), Japan (2,055), Australia (1,970), Germany (1,333), France (1,067), Belgium (1,004) and U.S.A. (994).

Andalusite.—Large deposits of andalusite sands have been investigated recently in the Marico and Zeerust districts, Western Transvaal. It is considered that these deposits could supply andalusite which, after concentration, would be suitable for use in refractories.

Barytes.—Production from a deposit in the Hay district, Cape Province, continues for local consumption, and grey, mid-white and super-white grades of ground barytes are prepared in Johannesburg from this mineral.

The production during 1935 amounted to 618 tons as compared with 1,705 tons for 1934.

Coal.—On the average, 70 collieries were in operation during the last quarter of 1935, there being a small decrease in both local consumption and in the export trade with an increase of 37,600 tons in the Bunker trade as compared with the previous quarter.

The coal exported goes chiefly to Ceylon, Dutch East Indies, Anglo-Egyptian Sudan, Portuguese East Africa, Strait Settlements, India and Kenya. Bunker coal was taken chiefly by Durban, Lourenco Marques and Cape Town.

The total production (less waste) during 1935 amounted to 13,359,509 tons.

Corundum.—The Union of South Africa is to-day the world's largest producer of corundum. Deposits are known in the Transvaal, Natal and Cape Province, but those in the Northern Transvaal are the only ones at present being worked. An abstract of a recently published Bulletin on corundum in the Union of South Africa will be found on pp. 246-248 of this BULLETIN.

No grain corundum has been produced since 1931 but production is understood to be contemplated again by the South African Corundum Co., Ltd., which has its works in the northern Transvaal.

The outputs of the several varieties of corundum for the years 1934 and 1935 were as follows:—

	1934. tons.	1935. tons.
Boulder	130	113
Concentrate	1	11
Crystal	2,728	4,140

The quantity of corundum exported rose from 2,426 tons in 1934 to 4,463 tons in 1935 and there is every indication that 1936 will see a still further substantial improvement in the export trade.

Gypsum.—The cement factories in the Union use a considerable amount of gypsum which is mostly obtained from large deposits in the districts of Kimberley, Boshof and van Rhynsdorp.

Diatomaceous earth (*Kieselguhr*).—Small quantities, supplied from the Ermelo and Pietersburg districts, are being manufactured into brick and other insulating products for local consumption by the Consolidated Rand Brick, Pottery and Lime Co., Ltd., at Olifantsfontein, Transvaal. Recently, a deposit was discovered on the farm Riffontein No. 406, Pretoria district.

Fluorspar.—There has been an increasing demand from the U.S.A. for high-grade fluorspar during the last quarter of 1935. Previous to this the market has been precarious with the result that work on several deposits ceased.

With renewed demands, an endeavour is being made to increase production. Exports increased from 200 tons in the third quarter to about 900 tons during the last quarter of 1935.

Messrs. Western Quarries Ltd. are erecting a plant in the Marico district, capable of producing 500 tons of ground spar per month, assaying over 98 per cent. of calcium fluoride and less than 1 per cent. of silica.

Production from the Warmbad area, Transvaal, continues mainly for local consumption.

During 1935, the production of fluorspar amounted to 1,727 tons as compared with 1,553 tons in 1934. The quantities exported, all of which went to the United States, were 1,102 and 809 tons for the years 1934 and 1935 respectively.

Kaolin.—Production for local use continues from the Potgietersrust district, from which the output during 1935 amounted to 226 tons as compared with 397 tons in 1934.

The deposits near Paulpietersburg, Northern Natal, are also being investigated by the South African Kaolin Co., Paulpietersburg, Natal.

Ochres and Oxides for Paint Making.—There was an increase, during the last three months of 1935, in local sales and exports of yellow ochres from the quarries in the Riversdale district, Cape Province, while Buffalo Oxides Ltd., continues to maintain sales of red oxides for local consumption.

The total production of ochres, etc., in the Union during 1935 was 3,900 tons as compared with 3,812 tons in 1934. The exports during 1935 were 3,377 tons, of which 3,170 tons were sent to the United Kingdom.

Magnesite.—No magnesite is exported, the production, which amounted to 1,462 tons in 1935, being used locally for the manufacture of magnesite bricks and carbon dioxide gas.

Talc.—The two producers in the Barberton district produce air-floated talc in various grades as well as talc pencils, the bulk of the output being used locally.

The output during 1935 amounted to 299 tons as compared with 235 tons for 1934.

Mineral Resources of the Somaliland Protectorate.—Hitherto there has been no recorded production of minerals in British Somaliland, excepting salt, which is obtained from sea water. More than twenty economic minerals have, however, been shown to occur in the Protectorate and some of these may ultimately prove to be commercially workable. At present, geological investigations are mainly directed to the discovery of serviceable water supplies for Government establishments and nomadic stock-owners. The following notes, compiled largely from the reports of R. A. Farquharson,

Director of Agriculture and Geology, and of the Imperial Institute, give an account of the more important mineral occurrences.

Salt.—Salt has been produced for many years by the solar evaporation of sea water in brine pans or pools in the neighbourhood of Zeila. Although the output amounts to only a few thousand tons per annum, the district is capable of a much larger production, since the area suitable for salt extraction is of considerable size and extends from Warabod, about 8 miles south of Zeila, to El Ghori, about 20 miles west of this port.

The industry is controlled by natives, who employ crude methods of extraction, some of the "pans" being, in places, mere holes in the ground. It has been shown, however, that a high-grade product can be obtained by simple purification methods, as indicated by the following chemical analyses, expressed in percentages.

	Zeila Salt* (not purified).	Zeila Salt* (purified).	Commercial Table salt.	High grade Table salt.
$NaCl$	96·24	97·50	97·40	98·40
$MgCl_2$	0·45	0·45	0·08	0·28
$CaSO_4$	1·30	1·26	0·58	1·30
Moisture	1·28	—	0·15	—
Insoluble residue	0·75	0·02	1·71	0·03
	100·02	99·23	99·92	100·01

* *Analysis made at the Imperial Institute.*

Exports of salt from the Zeila district during the 9-year period 1926-34 inclusive have been as follows, most of the material exported by land during recent years being consigned to Abyssinia.

SALT EXPORTED FROM BRITISH SOMALILAND

	cwts. By land.	By sea.	Total.
1926	19,089	22,444	41,533
1927	15,903	31,432	47,335
1928	14,736	18,822	33,588
1929	7,470	54,528	61,998
1930	8,356	12,282	20,638
1931	1,909	398	2,307
1932	39,219	845	40,064
1933	53,765	318	54,083
1934	62,822	394	63,216

Phosphate.—A deposit of phosphatic guano occurs on Mait Island, just off the coast and was worked for many years by the Sultan of Makulla for use in fertilising ground for tobacco cultivation. The deposit is not very thick or extensive and only small-scale operations are likely to be worth while.

Mica.—Mica of the muscovite variety has been found in several areas, notably the Mirsa plateau and the Golis Range. In 1927 a concession was granted to a syndicate to prospect a large area in the latter district. Much work was done, but although a quantity of mica was opened up, some of which was of good quality, so little was of commercial value that the concession was abandoned.

Petroleum.—An oil seepage at Dagaha Shabele near Berbera has been known for some years and several reports have been made upon the occurrence; but no drilling has been done up to the present.

Coal.—Coal has been found near Ankor and about 100 miles further east at El Ham-Ham in Eocene limestone, but the extent of the deposits is unknown and only surface samples have been examined chemically. One seam at El Ham-Ham is said to be 20 ft. long and 5 ft. thick. Whatever the value of the coal may prove to be, the deposits in general are so difficult of access that their commercial value will be seriously discounted by the cost of transport.

Gold and platinum.—Samples collected in 1928 during the investigation of the area extending from Haduya to Tug Had were assayed at the Imperial Institute and were found to contain small quantities of gold. In a ferruginous vesicular quartz from lenses in the slates on the north-east side of Haduya, platinum group metals amounting to 20 grains per ton were found in the first portion of the sample assayed, but negative results were obtained from the remainder of the sample.

Other minerals.—Other deposits of possible economic value include silver-lead ore, barytes, beryl and garnet. Considerable deposits of limestone and marble are also known to exist in the Protectorate.

The Mineral Deposits of Abyssinia.—Abyssinia is a plateau crossed by two lines of fracture which, coming from the western shore of the Red Sea and the south shore of the Gulf of Aden, converge near Ankober to form the Abyssinian trough in which lie the lakes Zwai, Shola, Margherita and Stephanie amongst others. To the north of this rift the plateau is composed of volcanic rocks apparently overlying Tertiary strata and a basement complex of crystalline rocks intruded by granites. To the south, in what is known as the Somali Plateau, Mesozoic strata predominate. Mineralogically, the localities in which the crystalline schists are found are the most interesting.

As is the case with every unexplored country, Abyssinia has been credited with great potential mineral wealth, but no authentic information of this is in existence. Prospecting

has been carried on sporadically by natives for centuries and in the seventeenth century the Portuguese reported the winning of gold in Wallega province on the western border. Silver and platinum have also been worked, but in the absence of any mining law, concessions to foreigners have been highly speculative.

Gold.—In the Wallega province, between the Didessa and Dabas tributaries of the Blue Nile, in the Weri river district and in the north between Adowa and Adigrat, alluvial and eluvial deposits of gold have been formed by the denudation of auriferous quartz veins traversing granite rocks. These deposits have been worked not only by natives, but also by an Italian company which explored some 40,000 sq. miles between Lake Tsana and Ashangi in the Tigre district and worked quartz veins in an area south-west of Adowa ; by a French syndicate in Wallega, and by an English concern at Mount Senaar to the north-west of the valley of the Blue Nile. All these districts are occupied by gneisses, mica schists, phyllites, granites and basic intrusions which fringe the Abyssinian plateau. The quartz veins are not persistent, but carry free gold and gold in pyrites in values ranging from 2 to 25 dwt. per ton. Approximately 9,500 oz. of gold are sent annually to Addis Abbaba from Wallega, but of recent years the Beni Shangul area in the extreme west over the Blue Nile has been the scene of much exploratory work and is now yielding two-thirds of the gold output of the country, about 21,900 oz. per annum. Occurrences of gold in Gojjan, Gurage and Shoa were surveyed in 1926 and others are known in Ankober and Gildessa.

Platinum.—This mineral was discovered during the last century on a tributary of the White Nile near Yubdo and is associated with ultra-basic rocks of which dunite (olivine rock) is the most platiniferous, but even this is not rich enough to justify working the primary rock. On the slopes of the Birbirite group of hills eluvial deposits are found and these, together with the alluvial deposits in the valleys, are worked in the same primitive way as the alluvial gold. A French concern was formed in 1926 to work these deposits, but since that time English capital has entered the company, which is stated to have been building a 120 mile road from Gambella and with much difficulty brought a small dredge from that town to the Birbir river. The platinum content of the eluvials increases as one approaches bedrock and attains a maximum in a yellow ochre bed which lies below the superficial red clays. The content of the whole bed rarely exceeds one-third dwt. per cubic yard. Platinum deposits are also known in the Kobe river valley and concentrations occur at the confluence of this stream with the Yubdo.

Mica.—In the Harrar district some 50 miles south of Dere Dowa, deposits of mica are found and have been exploited by an American company, but as yet the marketable product has scarcely paid the cost of its extraction. The mineral occurs in pegmatites traversing crystalline schists in proximity to granites which have intruded these rocks. These veins of pegmatite are exceedingly numerous and scattered over an area of 3,000 sq. miles, varying in thickness from a few inches to 30 or 40 ft. In a great number of cases the mica, a muscovite of ruby clear to heavily stained brown colour, sometimes of good quality, often cross-grained and cracked, occurs as large books. One of the features of these pegmatite veins is the presence of large garnets.

Mica occurs also in the Wallega district, in the Guinir district 200 miles south-west of Dere Dowa and in the Aossa district 150 miles north of that place.

Potash.—Close to the Eritrean border is the Assal salt plain, where in 1911 a deposit of high-grade potash salts was discovered. The salt plain has an area of 482 sq. miles and lies in a depression about 200 ft. below sea-level. Potassium chloride is found at the surface and the quantity of this mineral available was estimated in 1918 to be somewhat less than 140,000 tons. The upper layers of the deposit are 90 per cent. pure, but at depth the quality deteriorates to as low as 40 per cent. Considerable variation in the composition of the deposit occurs; at certain places sodium chloride predominates, but throughout, the quantity of magnesium chloride is low. Traces of bromine have been found in only a few cases. These deposits were exploited prior to 1918, but high transport costs checked further work. Potash also occurs in the Shabella district near Jig Jigga.

Coal has been proved at various localities on the plateau, but only a Tertiary brown coal and lignite are usable where the quality has been improved by alteration due to lava flows. The chief localities are Debra-Libanos, where a workable seam some 60 ft. thick occurs, Borro-Meda on Lake Tsana, Addis Abbaba, Ankober, Baltschi, Tegulette, Sallale, Debra and Borone. At Borro-Meda there occurs a bituminous coal, probably resulting from the alteration of brown coal by proximity to lava-flows. At Chelga, 20 miles north of Lake Tsana and west of Gondar, workable lignites are found over an area about 7 miles long by 2 miles wide. There are seven seams varying from one to six ft. thick. Coal is also reported in the Didessa valley.

Oil.—Deposits at Aussa in the Afar Plain, which lies near Eritrea, have been the subject of speculation recently. As the Mesozoic strata in the east are fairly thick, oil accumulations are possible, but owing to the presence of recent

eruptive rocks which cover the surface over a wide area, productive oil-bearing strata are likely to be limited.

Gemstones.—Turquoise has been worked intermittently by the natives at Got near Angolola and diamonds are reported near Uddur.

Sulphur.—Deposits occur in the Howash river valley in the Harrar district, in the Erta-Ali area in Dankalia and on the Dofane volcano in the Hausac depression.

Other minerals.—Mention has been made of tin, tungsten and apatite in the Harrar district, of cinnabar and asbestos on the River Lagare in the vicinity of Dere-Dowa and even radium in the same locality.

Silver is said to be present in Wallega and along the Harrar railway, while copper ores occur at Barasio near Acro. Iron and manganese ores are known in the Ghedem Mountains and the Chelga district and analyses of ore from the latter place showed 39·5 per cent. Fe.

The following is a list of the more important articles from which the foregoing statement has been compiled:—

O. GÜNTHER and F. HERMANN. "Die Bodenschätze Abessiniens." *Z. Prakt. Geol.*, 1935, **43**, 161.

J. KUNTZ. "Über Geologie und Bodenschätze in Abessinien." *Z. Prakt. Geol.*, 1936, **44**, 43.

ANON. *Glückauf.*, 1935, **71**, 1035.

E. MOLLY. "Le Oualbaza géologique et minier (Ethiopie)." *Chron. Min. Colon.*, 1934, No. 29, p. 252.

F. BLONDEL. "Le géologie et les ressources minérales de l'Ethiopie, de la Somalie et de l'Eritrée." *Chron. Min. Colon.*, 1935, No. 43, p. 306.

A. BORDEAUX. "Gisements de mica en Ethiopie en 1929. *Rev. Industr. Min.*, 1934, No. 246, Pt. 2, p. 101.

— "Les richesses minières de l'Abyssinie." *Ethiopie*, 1934, No. 1, p. 5.

— "The Development of Mining in Abyssinia." *Ethiopie*, 1934, No. 2, p. 10.

— "Les richesses minières de l'Ethiopie." *Ethiopie*, 1935, No. 6, p. 12.

S. J. JOHNSTONE. Potash (*Imperial Institute Monograph*), 1922, p. 22.

H. P. ROBERTSON. "Travelling in Abyssinia." *Min. Mag.*, 1929, **40**, 335.

— "Ethiopia's Mineral Wealth." *Engng. Min. J.*, 1935, **136**, 488.

Empire Nickel Developments.—Reference was made in the last issue of this BULLETIN (1936, **34**, 84) to the active development work being undertaken by the companies operating for nickel in northern Ontario, and recent bulletins from the Office of the High Commissioner indicate continued expansion in the Canadian nickel industry.

It is announced that by the end of this year production at the Falconbridge mine in the Sudbury district of northern Ontario will have been increased by 25 per cent. This results from the decision of the directors to expand plant facilities both at Sudbury and at the company's refinery in Norway. In deciding to enlarge the scale of operations, the directors

were influenced by the increased ore-reserves available, greater market demand, and a desire to increase stocks on hand. The necessary construction work, however, will postpone the contemplated increase in output until towards the end of 1936.

The tonnage of ore treated last year at the Sudbury plant of Falconbridge Nickel Mines was about 10 per cent. in excess of that for 1934. As a result of sinking the new No. 5 shaft and lateral work on the 500 ft. level, an aggregate ore length of 4,500 ft. has been opened up and there is stated to be reasonable assurance that the total length will be at least a mile. While somewhat less work has been done on the 1,200 ft. level, the only other horizon opened up from the new shaft, it is evident that this level is also indicating greater length.

Electrical energy from the Abitibi Canyon power plant was made available recently for the No. 5 shaft and, with the installation of the new hoist, greater progress will be made in opening the eastern section of the property during the coming months. This shaft has a hoisting capacity of 3,000 tons per day of 16 hours.

A 25 per cent. increase in capacity should provide an annual output of about 14,000,000 lb. of nickel in matte and 6,680,000 lb. of copper in matte. At the beginning of 1935 the ore reserves of the Falconbridge mine were given as 2,960,238 tons, averaging 2·04 per cent. nickel and 0·9 per cent. copper. During the year approximately 300,000 tons of ore were treated, as against 272,000 tons in 1934.

Falconbridge Nickel Mines, Ltd., has recently opened at Orillia (Ontario) the plant of its subsidiary company, Fahralloy Canada, Ltd., in which Ventures, Ltd., is also interested. By means of the electric furnace process, the plant will produce a complete range of nickel steels, containing from 2 per cent. to 80 per cent. of nickel, the proportion depending upon the purpose in view. The metal used at Orillia is being purchased from the International Nickel Company in order to obviate the cost of shipping nickel back to Canada from the Falconbridge Co.'s Norwegian refinery.

According to *The Northern Miner*, the nickel consumption of the world in 1935 is estimated at 160 million lb. Of this total, International Nickel sold 125 millions, Falconbridge 11 millions, and the remainder of the world—New Caledonia, Norway, and others—24 millions. The last figure includes an allowance for used nickel which, however, is a small item because a large proportion of the metal loses its identity in use and consequently is not salvaged. According to the same authority, the sales of metal by the International Nickel Co. early in this year were proceeding at an exceptionally active rate.

It is reported that recent developments on a group of 35 claims located east of the Falconbridge mine in the Sudbury area have disclosed an interesting deposit of nickel-copper ore on which a diamond-drilling campaign is to be commenced in the near future.

Other Empire nickel developments have been reported recently from British Columbia and South Africa.

It is reported that operations are proceeding steadily at the property of the British Columbia Nickel Mines, Ltd., near Choate, Yale District, British Columbia, in order to test the grade and extent of the ore-bodies located to date. According to the *Metal Bulletin* (December 17, 1935, p. 16), 957,000 tons of ore averaging 1·37 per cent. nickel and 0·45 per cent. copper have been blocked out, with good prospects of a further 500,000 to 1,000,000 tons being developed in the near future. 2,000,000 tons are stipulated as a prerequisite for the construction of a mill, and diamond drilling is being continued to test the 1,600 ft. ore-body.

In April, it was reported in the Canadian press that drilling at Choate had encountered the richest veins so far found in the mine, one of which assayed 3·2 per cent. nickel and 1·10 per cent. copper. It is believed that these discoveries are a downward continuation of the mine's Pride of Emory ore-body and that the latest developments raise the average grade of ore to 1·41 per cent. nickel. The ore is stated to contain small values of gold, silver, and rare metals in addition to nickel and copper, and that it lends itself readily to concentration on a five to one ratio. It is understood that the British Columbia Nickel Mines Co. is studying the question of market outlets for concentrates in Japan and Europe, pending the provision of its own metallurgical plant. Apparently it is not intended to produce refined nickel at the property, but to sell a matte containing about 80 per cent. nickel.

South African Minerals, Ltd., are interested in the development of a nickel-copper occurrence in the Bushveld igneous complex west of the Pilandsbergen, Northern Transvaal, and a preliminary report on this field by C. M. Schwellnus of the Geological Survey Division of the Department of Mines has been published (*Geological Series Bulletin No.* 5, Govt. Printer, Pretoria, 1935). The area comprises the farms Vlakfontein No. 902 and Groenfontein No. 302 at the two extremities of a broad zone of basic rocks along which gossans are distributed. The direction of the zone is in a broad curve roughly parallel to the outer fringe of the Pilandsbergen. The opaline gossans merge into sulphides at depths varying from 20 to 50 ft. below the surface and the evidence obtained from various widespread occurrences suggests that all existing gossans can reasonably be regarded

as caps over ore-bodies, the extent of which will have to be proved by future mining development. For the sake of centralisation, the company's mining activities are at present confined to their freehold portion of Vlakfontein No. 902. The form of the ore-bodies has not yet been determined, but it is stated that at least 100,000 tons of ore have been proved to date.

In 1933, Dr. Focke collected representative samples at random from the ore-bodies as well as the dumps. His average percentage results were as follows: Fe 37·2, Co 0·3, Ni 3·0, Cu 0·73. In all Focke's 18 samples assayed there has been found cobalt, gold, platinum, and silver. The assays show that the precious metals which seem to be present in sufficient quantities to enhance the value appear to be distributed throughout the ore. It is claimed that, on the average, the Vlakfontein ore contains less copper but more nickel than the average Sudbury ore; for instance, the grade of ore treated by the Falconbridge Nickel Mines in 1935 was 2·048 per cent. nickel and 0·985 per cent. copper.

The report states that South African Minerals, Ltd., are at present erecting a plant which they are confident will work profitably. The scheme to be adopted is briefly as follows: (1) Preliminary roasting to reduce the sulphur content, (2) smelting of the partially roasted ore in blast furnaces—the precious metals are automatically concentrated in the matte, (3) de-ferration of the matte in a converter to produce a rich matte containing 80 per cent. nickel. The final matte is to be exported for refining.

Petroleum in Great Britain.—For over three hundred years numerous instances have been recorded of the occurrence of petroleum residuals, seepages and hydrocarbon gases throughout Great Britain. In 1667, gas from a spring near Wigan was collected and successfully burned. Petroleum was found exuding from a Liassic limestone near Bristol in the year 1811 and in 1829 a well near Shepton Mallet, Somersetshire, yielded several barrels of light-coloured oil which flowed into the water-well supplying an isolated dwelling house.

At Coalport the tar spring, as Prestwich records (*Trans. Geol. Soc.*, 1837, **5**, 438), yielded 1,000 gals. of oil per week for a time, from a Coal Measures sandstone and later Binney and Talbot (1843) described petroleum indications at Doun Holland, Formby, Lancashire. Previously, in 1836, natural gas was noticed in a well at Hawkhurst near Heathfield, Sussex, which was sunk in the Wealden Beds. The gas issued from a cavity encountered at a depth of 148 ft.

A most important accidental discovery of petroleum followed in 1847, when a stream of oil was found flowing

into the top of a coal working at Riddings Pit, Alfreton, Derbyshire. For more than a year seven to ten barrels per day were collected from this source and sent to James Young's refinery, where burning oil, lubricating oil and paraffin wax were separated.

Another occurrence recorded in Derbyshire is that of liquid petroleum in lead veins in the Upper Carboniferous limestones and Yoredale shales, but in no case has the amount in this occurrence been sufficient to justify exploitation.

In Yorkshire, the roof of the Parkgate seam at Manvers Main Colliery near Rotherham yielded in three days (1902) about 7,800 gals. of greenish black oil which, on standing, rapidly set to the consistency of vaseline. Brine accompanied this oil, which very soon spent itself, leaving only oozes.

Shows of oil have also been observed in borings put down at various times in Notts., Lancashire, Cumberland, Durham and South Wales, but there has been no particularly valuable output anywhere, except at Kelham, near Newark, where a test-boring for coal, penetrated a loose brownish sandstone 15 ft. thick at a depth of 2,452 ft. Oil flowed regularly during the eleven months the hole remained open, even though it was full of water. The yield was five to six gallons per day.

Intensive search for oil really commenced in 1918 when Lord Cowdray, of Messrs. Pearson & Sons, offered the free services of his geological staff for oil exploration in Great Britain, on the understanding that indiscriminate drilling would be prevented by legislation. The Government accepted the offer and voted £1,000,000 to meet the cost and the firm carried out the work of surveying and drilling, their American geologists selecting the sites for boring. In November 1918, the Petroleum (Production) Act was passed, which prohibited drilling for oil except under licence.

Conditions requisite for the formation of a petroleum reservoir consist of a porous stratum, or oil sand, covered by an impervious capping of clay or shale and where these occur an anticlinal feature is needed to induce local accumulation of oil. In Derbyshire and Staffordshire the Carboniferous limestone was considered to be a likely reservoir because of its porosity and capping by the shales of the Upper Carboniferous limestone series and those of the Coal Measures above the Millstone Grit. The various seepages of oil in this area were taken as further indications of underground reservoirs and by the end of June 1919 eleven boreholes had been drilled by the American cable method; seven in Derbyshire, two in North Staffs. and two in Scotland.

The average depth of all these borings amounted to some 3,000 ft., but only the Hardstoft Boring, Derbyshire, put

down on a local anticline (Brimington) encountered oil in any measurable amount per day. At 3,075 ft. it began producing seven barrels or a ton of oil daily and a pumping test in April 1921 gave 14·6 barrels per day. On its natural flow, the well was giving 21 barrels a week in 1922 and since that date the yield has steadily declined to an almost negligible figure.

In Scotland, the D'Arcy Boring put down 9 miles south-east of Edinburgh, on a well-defined dome structure, struck natural gas (largely methane and ethane with 0·33 per cent. helium) at 724 ft., estimated to be flowing at the rate of 300,000 cu.ft. per 24 hours. This was cased off and drilling continued until at 1,080 ft. oil was struck in a soft sandstone, but further drilling failed to increase production. When the oil was first encountered it rose to about 70 ft. from the bottom of the bore and a week later the column had risen to a height of 320 ft. In order to determine what production could be obtained, bailing was begun, but the quantity of oil accumulating was not sufficient to enable this work to be carried on for more than a few hours a day. In all, during two months only seven tons of oil were obtained from the well.

Government drilling came to an end in 1921 and in March 1923 the Hardstoft No. 1 Well was handed over to the Duke of Devonshire, the owner of the mineral rights. During the time it was in the hands of the Government it had produced 1,088 tons of oil. Cleaning of the well so improved its output that it was decided to drill a second well on a site chosen 600 ft. west of No. 1; but even at this short distance the strata penetrated showed great divergencies from that in the older boring, due to unsuspected faultings. Oil and gas "shows" were recorded in the Coal Measures, but only a trace of oil was found at the top of the Carboniferous limestone, at a depth of 3,056 ft., which corresponded to the producing horizon of Well No. 1. A strong flow of brine was met at 3,125 ft. and the well was abandoned at 3,130 ft.

Hardstoft No. 3 was located 600 ft. eastwards of Well No. 1 and here again "shows" of oil were noted in the Coal Measures. What was assumed to be the Carboniferous limestone was reached at 3,260 ft., but no trace of oil was observed. The well went to 3,825 ft. and was given up after penetrating lava to a thickness of 200 ft.

The evidence from these borings seems to indicate that neither the Millstone Grit nor the Carboniferous limestone contains oil in commercial quantity and that Hardstoft No. 1 Well was fed by oil migrating from a deeper source, up the fault plane which is cut by the boring. This 1 : 2 ratio of successful to barren wells is not a poor one as compared with other fields abroad. In the Kettleman Hills Oil Field, California, 37 wells, representing a total of 102,253 ft. drilled,

were sunk prior to commercial production being obtained and in Soulturn, California, in 323 holes, averaging 4,000 ft., there were about 244 miles of unsuccessful drilling (*Petr. Times*, 1926, **16**, 1000). In Derbyshire, on what may be equally considered a single structure, nine wells of a total footage of 33,031 ft. were drilled against a production of nearly 3,000 tons of oil.

In the south-eastern corner of England the buried Palæozoic structure is not well known, there being few deep bore-holes in the area. Oil seepages have been noted at Kings Lynn, Downham, Littleport and Ely in rocks of Jurassic age and disposed roughly in the Caledonian (N.E.-S.W.) trend, but their derivation is uncertain and they may possibly emanate from a deep-seated source. Near the Kelham Boring, previously mentioned, two wells have been drilled for oil, but only small amounts of no commercial value were produced.

A bituminous shale in the Kimmeridge clay of S.E. England has been used locally as a fuel ("Blackstone" in Dorset). The "Blackstone" bed of Kimmeridge Bay is anticlinal in form and should favour the accumulation of petroleum, but neither this nor natural gas has been observed there. The oil-shales of this formation have been exploited for distillation purposes by several companies, but no attempt, as far as is known, has been made to locate petroleum. Perhaps below this clay stratum investigators may be expecting oil accumulations in the lower measures (Middle Oolites, etc.).

Natural gas has been observed in places near Heathfield in Sussex, issuing apparently from the Wadhurst Clay, the Ashdown Sands, or the marls and shales of the Purbeck beds. The Natural Gas Fields of England, Ltd., 1902, made several borings around Heathfield, which provided gas for the lighting of that village.

The investigation of petroleum possibilities which ceased in 1921 has again become popular and a subsidiary of the Anglo-Iranian Petroleum Co., under the title of the D'Arcy Exploration Co., has taken licences to drill for oil in extensive areas in S. and S.E. England, the Isle of Wight, Yorkshire, Lincolnshire, Nottinghamshire, Leicestershire, Cambridgeshire, Norfolk and in the Lothians in Scotland. The first site chosen is at Paulsgrove, north of Portsmouth Harbour, where permission to bore has been granted by the local authorities and a drilling plant capable of working to a depth of 10,000 ft. is being used.

Another company started drilling operations in 1931 at Worth, Sussex, on an anticline and a second attempt reached a depth of 1,886 ft. A new site has now been chosen on the same anticline and the company, now known as Kent and

Sussex Oilfields, Ltd., has been granted permission to erect the necessary drilling rig. All these recent activities indicate that in spite of the meagre results hitherto attained in the search for oil in Great Britain, the scientific evidence available is sufficient to warrant further test drilling as well as geological and geophysical investigations.

Considerable changes in regard to the conditions under which prospecting for and working petroleum deposits could be carried out in Great Britain were introduced by the Petroleum (Production) Act of 1934 and the Regulations issued in connection therewith. This Act provides that the ownership of any naturally occurring petroleum in Great Britain is vested in the Crown and this enables licences to be granted over sufficiently large areas and removes any difficulty in regard to claims for payment of royalties. Auxiliary rights may also be granted under the Mines (Working Facilities and Support) Act, 1923, by the Railway and Canal Commission, should it be satisfied that these rights cannot be obtained on reasonable terms by voluntary arrangement with the landowner and that it is in the national interests to grant the rights.

Licences are of two types—prospecting and mining, the first covering areas of 8 to 200 sq. miles and the second areas of 4 to 100 sq. miles. Prospecting licences are granted for three years and may be renewed for two further periods of 12 months each. Mining licences are for a first term of 50 years with the option of renewal for a further period of 25 years. Both prospecting and mining licences are available to foreign interests provided the latter have a British working organisation, but the majority of the persons engaged in the search for oil on behalf of any licensee must be British.

Provisions are made which prevent rights or any oil areas discovered passing into foreign control. The grant of a licence depends on the possession of adequate financial backing and technical resources, the financial security demanded being £6 per sq. mile with a minimum of £400 for a prospecting licence and £20 per sq. mile with a minimum of £1,000 for a mining licence.

Regulations also cover the observance of good drilling technique, avoidance of damage to local amenities, provisions against competitive off-setting and, where oil should be discovered, the insistence on the principle of unit-development.

The rates of royalty payable to the Government are to be fixed by the Treasury for each licence and these may not be less than 3*s*. nor more than 6*s*. per ton on crude oil produced and not less than one-eighth of a penny nor more than 2*d*. per Imperial gallon in respect of casing-head petroleum spirit obtained.

Corundum in South Africa.—Although for many years artificial hard abrasives have been used in much greater amounts than natural corundum, there is still a good demand for the natural abrasive for certain purposes. For some time this demand has been met almost exclusively by supplies from South Africa, where sales and shipments in 1935 amounted to 4,263 tons.

This material and the deposits from which it is obtained have recently been described in detail by W. Kupferburger in *Bulletin No. 6, Geol. Series, Dept. Mines, Union of S. Afr.*, which is a publication of 81 pages entitled "Corundum in the Union of South Africa."

The principal deposits are distributed over an area of some 3,000 sq. miles in the northern and north-eastern Transvaal in the districts of Pietersburg, Zoutpansberg, Letaba and Lydenburg and the corundum occurs both in original or primary deposits (reef corundum) and in detrital deposits derived from them by denudation. The corundum-bearing igneous rocks are believed to have resulted from the desilication of pegmatite magma by interaction with the basic rocks into which it was intruded and the chief economic source of corundum is a rock called plumasite composed essentially of felspar and corundum with a varying amount of dark-coloured mica. In the eastern Transvaal the felspar has often been altered by hydrothermal agency to margarite and the rocks are known as marundites. In some cases this hydrothermal alteration has been detrimental to the abrasive quality of the corundum. There are also gneissic deposits of less importance.

The deposits generally occur as lenticular intrusions of variable width, from a few inches to 25 ft., the greatest length being about 200 ft. In most cases the workings have not been carried to more than 20 ft. from the surface. There are probably less than a dozen deposits containing between 5,000 and 10,000 tons of rock, the majority having only a few hundred to 1,000 tons, the average corundum content being not more than 40 per cent.

The eluvial deposits are very variable both in type and richness. They are more widespread than the primary deposits and for many years provided the bulk of the production. In the majority of those which have been worked the content of corundum has been between 10 and 20 per cent. by volume.

The four forms in which corundum may be exported, according to the Government Export and Grading Regulations, are designated boulder corundum, crystal corundum, corundum concentrate and grain corundum.

Boulder corundum is rock containing a high percentage

of corundum, which has not been subjected to any form of mechanical treatment. It was the first variety to attract attention but has gone out of favour owing to the difficulty of crushing and cleaning to produce grain. For export it is sold on the basis of a minimum alumina content of 65 per cent. and the value varies according to quality from 50*s*. to 70*s*. per long ton f.o.r. Attempts are being made to crush and roughly concentrate this material for sale in competition with emery.

Crystal corundum includes all loose crystals and fragments larger than $\frac{1}{8}$ in. which have been freed as far as possible from adhering impurities. This is the form in which most of the mineral is exported. Practically the whole output goes to the United States where there is an established market, the raw material being converted into abrasive grain for use in the manufacture of grinding wheels, etc.

According to the grading regulations for crystal corundum, four main classes are recognised on a basis of total alumina content, thus: A contains not less than 92 per cent. Al_2O_3, B contains less than 92 per cent. and not less than 90 per cent., C contains less than 90 per cent. and not less than 85 per cent., D contains less than 85 per cent. Each of these is subdivided into four grades according to size, thus: No. 1, retained on $\frac{1}{2}$ in. round-hole screen; No. 2, passing $\frac{1}{2}$ in. and retained on $\frac{1}{4}$ in. round-hole screen; No. 3, passing $\frac{1}{4}$ in. and retained on $\frac{1}{8}$ in. round-hole screen; No. 4, a mixed grade retained on the $\frac{1}{8}$ in. screen. In actual practice only grades A1, A2 and B3 are exported, which means that the minimum alumina-content of coarse and medium sizes is 92 per cent., whereas for the fine size a minimum of 90 per cent. alumina is accepted. The present prices for these three grades are about £8 to £9, £7 to £8 and £5 to £6 per short ton f.o.r. respectively.

Corundum concentrate is the product obtained by crushing boulder or other corundum to less than $\frac{1}{8}$ in. size and eliminating gangue minerals. When this product is screened to certain particular degrees of fineness for use in making grinding wheels and other abrasive goods it is known as grain corundum.

Grain corundum is classified according to alumina content in the same way as crystal corundum and is then graded by sieving into the following sizes in general use: 6, 8, 10, 12, 14, 16, 20, 24, 30, 36, 40, 50, 60, 70, 80, 90, 100, 120, 150, 180, 220, the numbers being the meshes per linear inch of screens through which the grains will just pass. That which is finer than 220 mesh is known as flour or F grade and this is further graded by settling in water for varying times. Thus 28, 32, 40, 50 and 60 minute F grades are obtained.

Mining is done by somewhat primitive methods using

for the most part picks and shovels and recovery and cleaning of the corundum is also mainly performed by hand methods assisted by the simplest home-made devices contrived out of petrol drums, on the lines of a tube mill. Mills for preparing grain corundum have been employed but operations ceased in 1931. It is hoped to recondition the mills and resume work in the near future.

The United States takes 90 per cent. of the Union's corundum output and of this it is estimated that 70 per cent. is made into abrasive wheels, 20 per cent. into grain and flour for grinding and polishing glass, etc., and about 10 per cent. is used in making specially pure fused alumina. Corundum is also used in highly refractory crucibles and for providing non-slip surfaces to stair-treads.

Corundum has many competitors in the abrasive field and although the fact that it has been successful in maintaining a market in the United States may be due in part to its special suitability for certain purposes, it seems probable that it is largely due to the existence in that country of a single channel for its distribution and sale and to the efforts of the firm in question in establishing a market. Other manufacturing countries have been able to use emery and artificial abrasives in place of natural corundum and the prospects for the future expansion of the industry seem to lie in the direction of establishing a selling organisation for the South African product in those countries, backed by an efficient system to ensure that regular supplies of standard quality shall be available at all times.

Indian Gemstones.—The *Asiatic Review* for April 1936 contains an interesting contribution by G. H. Tipper on Indian gemstones.

India is fortunate in possessing deposits of some of the most beautiful and valuable precious stones. The rubies of Upper Burma have been known for many centuries and their quality has never been surpassed by stones from other localities. The sapphires of Kashmir originally came to light as the result of a landslide in 1882. The deposits became depleted and the mines were abandoned, but within recent years the State Mineral Survey Department has located a further deposit from which many fine stones have been obtained. Kashmir sapphires are usually regarded as the finest in the world, but many fine stones have also come from the Ruby Mines area of Burma.

Chinese jade ornaments, of which such a fine collection was shown at the Exhibition of Chinese Art recently held at the Royal Academy, are cut from jadeite which comes from mines in the Myitkyina district of Upper Burma.

The famous diamond mines of Southern India associated with the romantic city of Golconda supplied the world with diamonds until the Brazilian fields were found in the latter half of the eighteenth century. Many stones famous both in fact and fable, among them the Koh-i-Noor, are reputed to have come from these deposits. They are no longer actively exploited, but there is still a small diamond production in Central India centred around Panna.

Tourmaline, spinel, garnet, beryl, agate and many other semi-precious gemstones are also obtained in various parts of the country, which is in fact a storehouse of all the important gemstones except emerald.

Cerium-Iron Pyrophoric Alloys.—Mischmetall, which is a mixture of 40 to 50 per cent. cerium with smaller amounts of lanthanum, neodymium, praseodymium and other rare earth metals, easily forms alloys with both heavy and light metals. Many of these alloys have found technical applications, as they possess the peculiar property of emitting sparks when struck with a hard substance, that is, they are pyrophoric.

The production of these pyrophoric alloys has been described recently by Heinz Foelsch (*Chem. Ztg.*, 1935, **59**, 1036-1038). Von Welsbach was one of the first to recognise the importance of these alloys and initiated their production in Austria. The manufacturers of mischmetall in Germany, Austria and France, who account for about three-quarters of the world's production, have agreed to market the metal only in the form of pyrophoric alloys. These alloys usually contain 18 to 30 per cent. of iron with smaller proportions of zinc, aluminium, magnesium, copper and silicon. Cerium is the essential constituent; if the mischmetall contains less than 35 per cent. of the element, or if other rare earth metals are substituted, the alloys are useless.

The mischmetall used is given a preliminary purification by melting it under a fused mixture of sodium and potassium chlorides in a crucible and pouring it into moulds. The pyrophoric alloys are best prepared in a furnace containing a bath of molten salt in which the crucible is immersed, so that its contents do not come into contact with injurious gases. The metal is covered with a layer of molten chloride of sodium, potassium or barium, the latter being usually employed, although the poisonous nature of its vapour is a detriment. Common salt is used for low-melting alloys.

Clay or zirconia crucibles can be employed, but those of graphite, if used, must be well lined with alumina or magnesite to prevent the formation of carbides.

The molten mischmetall is kept at a temperature of about 1,100° C. and the other constituents are added, iron as powder

wrapped in aluminium foil, magnesium and zinc together as an alloy. Some metals, such as zinc, dissolve with considerable evolution of heat. The antimony alloys spark very freely but the heat evolved in their preparation is so great that they cannot be made on a commercial scale. Light metals such as magnesium and aluminium can be added to reduce the weight of the alloy, but they often render it brittle and unstable in air. Not more than 12 per cent. of magnesium should be present.

The alloys produced have to be cast; they cannot be pressed into shape as the crystal structure is thereby altered. The moulds, which are narrow tubes of sheet metal bound into bundles, are heated to 800° C. and placed in a metal box packed round with dried sand, before the alloy is poured into them. Cooling, which should be slow, must be carried out with extreme care as slight variations in the conditions considerably affect the properties of the alloy and the spark-producing power may be completely lost if the alloy is suddenly chilled. After cooling, the moulds are emptied and the rods produced broken into pieces of the size required for "flints." These are pickled in 1 to 2 per cent. hydrochloric acid, given a thin covering of linseed oil to protect them from oxidation and coated with aluminium powder. They are finally polished in a rotating drum with dry sawdust, sorted, and packed for distribution.

The Dead Sea Potash Industry.—The Dead Sea, lying at an average depth of 1,300 ft. below the level of the Mediterranean, is the collecting basin for the waters of the River Jordan, the wadis from the east, south-east and south and certain underground springs on its western coast. The only method of discharge for this water is by evaporation by solar heat and almost continuous winds from the north and south which rapidly disperse the vapours during the eight totally rainless months of the year. The evaporation process does not preserve equilibrium with the in-flow and the level of the sea fluctuates through an annual range of about 30 in. The total volume of water in the sea is estimated at 158·9 cubic kilometres and the quantities of salts in solution (in million metric tons) at approximately: potassium chloride, 2,000; sodium chloride, 11,000; magnesium chloride, 22,000; calcium chloride 6,000; magnesium bromide, 980.

The main source of supply of these salts, except the bromide, is the River Jordan, the water of which contains only traces of bromide. The lake supplies of bromine may have been derived from the hot springs of Tiberias and Herod's Bath in the north-east corner. The waters of these hot springs show a high bromine content.

A considerable amount of work has been carried out with a view to separating and marketing a number of the compounds present in Dead Sea water and the interesting details given below regarding this work have been taken from a paper recently given by M. A. Novomeysky before the Institution of Chemical Engineers.

The chemical composition of the Dead Sea waters, which represent a sodium chloride brine almost saturated with other salts, changes from the surface downwards with the increase in specific gravity, as shown in the following analyses :

	Surface.		Depth 175 ft.	Depth 360 ft.
KCl	9·96	11·80	14·7	15·67
$NaCl$	70·96	82·40	84·2	87·38
$MgCl_2$	109·50	142·40	163·7	169·04
$CaCl_2$	31·01	33·0	47·5	46·66
$CaSO_4$	1·32	1·3	0·6	0·64
$MgBr_2$	4·45	3·9	5·9	7·30
Total salts (grams per litre)	227·10	274·8	316·6	326·69
Specific gravity	1·1646	1·1725 (temp. 23° C.)	1·224 (temp. 23° C.)	1·2343

Chemical investigations were initiated in 1911 and proved that over 90 per cent of the sodium chloride, over 80 per cent. of the potassium chloride and a large proportion of the magnesium chloride could be removed by fractional crystallisation. Experiments on the extraction of potash by solar evaporation, which began in 1921, were also successful and revealed that the salt could be recovered as carnallite containing 20 per cent. of potassium chloride, by evaporation in open pans and that the carnallite could be converted to high-grade potash by a single treatment with cold water.

In February 1930 constructional work was begun by Palestine Potash Limited, on a plant to carry out the extraction on a commercial scale. A year later a bromine plant with a daily capacity of one ton was in operation and in February 1932 the first few hundred tons of high-grade potash salts were dispatched. By the end of that year 10,000 tons of potash salts and 250 tons of bromine had been produced. Based on the results of the experience gained the plant has now been enlarged to produce 25,000 to 30,000 tons of potash salts and 1,000 to 1,200 tons of bromine per annum.

The plant is situated on the flat ground on either side of the River Jordan near where it enters the Dead Sea and during the first two years the brine for filling the pans, which have areas ranging from 7½ to 30 acres, was drawn from the surface of the sea. In 1932, a 30 in. pipe-line was laid on the bottom of the sea to a depth of 175 ft. and the water pumped

to the highest pans of the series at a rate of 500,000 gals. an hour. Owing to the high specific gravity (1·225 to 1·227) of the brine drawn from this depth, precipitation begins immediately the liquid reaches the pans and continues till a specific gravity of 1·31 is reached, when the residual liquor enters the inner pans arranged round the plant. Here carnallite (double chloride of potassium and magnesium) is deposited, together with varying amounts of sodium chloride.

To enable the carnallite to be removed from the pans continuously, small dredges capable of floating in 5 to 6 inches of brine have been devised and thus crystallisation goes on throughout the year. From the pans the carnallite slurry is pumped through floating pipes to separators which retain the solids, while the liquid, now of specific gravity 1·33 to 1·34, passes to a lower series of pans where magnesium chloride is deposited as large crystals during further evaporation. A part of the final brine from these evaporators, of 1·37 to 1·38 sp. gr. and containing 13 to 14 grammes of bromine per litre, is pumped to the bromine factory where this halogen is extracted by treatment with chlorine and steam. The greater part of the ultimate liquid waste is returned to the sea except for a small quantity which is treated with slaked lime to produce impure liquid calcium chloride.

The conversion of the carnallite to artificial sylvinite takes place in large cylindrical mixers into which the slurry from the separators is washed with fresh water. Experience has shown that in the decomposition process ½ ton of water to one ton of carnallite is required and the process takes 35 to 40 minutes. The solid sylvinite is separated in rotary vacuum filters, conveyed to settling tanks of 120 tons capacity where the final product is high-grade potash salt with 80 to 99 per cent. potassium chloride. The sylvinite is freed in these tanks from the sodium and magnesium chlorides by cold fresh water spraying, one or more of such treatments or a final spray with brine saturated with potassium chloride resulting in a product of any purity up to 99 per cent. potassium chloride. The final product is dried and packed in bags or shipped in bulk.

Since flat land at the northern end of the Dead Sea suitable for the construction of pans is limited, an extension was begun at the southern end, where an area of about 60 sq. kilometres of suitable land is available. Ultimately the total capacity of the plant will exceed 100,000 tons of potassium chloride per annum.

Magnesium Compounds from Sea Water.—A method of producing magnesium salts from sea water, which is being carried out on the inland shores of San Francisco Bay, has

been described recently by P. D. V. Manning (*Chem. Metall. Engng.*, 1936, **43**, 116). The plant, which has been operating for the past ten years, produces 22 different magnesium compounds and has a daily output of about 10,000 lb. of various types of finished carbonates, hydroxides and oxides. The water employed seldom contains more than 80 per cent. of the normal saline content of sea water and 100 gals. of bay water are pumped to produce 1 lb. of MgO. A typical analysis of the water used, in grams per litre, is as follows :—

$NaCl$	27·319			$Ca(HCO_3)_2$	0·178
$MgCl_2$	4·176	MgO	2·2	K_2SO_4	0·869
$MgSO_4$	1·668			R_2O_3	0·022
$MgBr_2$	0·076			SiO_2	0·0076
$CaSO_4$	1·268			B_2O_3	0·0285

The reaction is a simple one based on the precipitation of the magnesium as hydroxide by addition of slaked lime, but the permissible quantity of impurities in the final products necessitates careful practical consideration. Suspended impurity such as colloidal clay and carbon dioxide in the form of bicarbonate are removed from the water by chlorination, addition of a slurry of calcium hydroxide, settling, crystallisation of the calcium carbonate formed and finally filtration through sand filters. The water leaves the filters in a soft, sterilised and clarified condition and is stored in concrete tanks.

The other raw material, lime, is a special high-calcium oxide, which is screened and slaked with specially-treated water. The reject from this process is used in the purification of the sea water and the slurry is screened to 200 mesh before being mixed with the water. After the reaction is complete the products pass to a Dorr thickener on which the magnesium hydroxide settles and the mother liquor containing calcium chloride, calcium sulphate, some calcium carbonate and chlorides of sodium and potassium passes to waste.

The finely divided hydroxide is washed free from calcium and magnesium chlorides in a tower in which an upward current of purified water flows and as it settles, passes out through holes in the base, to be filtered automatically. The basic magnesium carbonate is prepared by subjecting the hydroxide to the carbon-dioxide-rich flue gases from boilers fired by natural gas and boiling the precipitate in steam.

Until about three years ago only two types of basic magnesium carbonate were known, but now eight different carbonates are made at this plant, each in different grades. These are used as coating agents for various substances; in the production of printing inks, the manufacture of pharmaceutical preparations, pastes, soaps, tooth powder; in paints and varnishes, and in compounding rubber.

Some New Industrial Uses of Nitrogen Compounds.—Some recent developments in the industrial uses of ammonia and its salts were dealt with at a recent meeting of the Leeds Section of the Institute of Chemistry in a lecture given by M. P. Applebey (*Journ. Proc. Inst. Chem.*, 1936, Part I, 49).

Ammonia gas can be conveniently used as a source of hydrogen for some metallurgical purposes, the mixture of three parts of hydrogen to one of nitrogen obtained by "cracking" ammonia being satisfactory in use and cheaper than pure hydrogen within certain limits of consumption. Nitrogen containing limited amounts of hydrogen for use as an inert atmosphere for bright annealing and other metallurgical processes can also be obtained satisfactorily from ammonia gas by the use of a special burner.

The use of ammonium salts as fire-proofing agents has been known for a considerable time and improved products are now on the market which contain ammonium sulphate and ammonium phosphate together with a penetrating agent which makes treatment easier and more effective.

Ammonium salts may also be used in glass manufacture. The addition of a volatile salt such as ammonium sulphate to the batch gives a product of greater homogeneity and one that permits of increased light transmission, more rapid melting and greater uniformity of behaviour with regard to chemical reagents. These effects have been shown to be largely due to the lowering of surface tension and viscosity which this agent produces. Ammonium phosphate is also used in the production of opal glass and of glasses of high chemical resistance.

Lead Titanate—a New Paint Pigment.—Lead titanate which is now being produced on a semi-commercial scale in America, results from the interaction, at a high temperature, of lead monoxide (litharge) and titanium dioxide.

The following details regarding the pigment have been taken from an account by D. W. Robertson in *Industr. Engng. Chem.* (*Industr. Ed.*), 1936, **28**, 216.

In colour, it is pale yellow and its reflection characteristics in the visible spectrum show that it can never be used as a white pigment, although it can, of course, form the basis of a paint of any ordinary tint, with the possible exception of a light blue-grey. It possesses an extremely high refractive index and, in paint vehicles, exerts a correspondingly high opacifying effect. It can, therefore, be safely reduced with a considerable percentage of non-hiding or low-hiding pigments. The particles are, like those of titanium dioxide, very small and comparatively uniform in size, and are free from acicularity.

Lead titanate possesses some interesting chemical properties. It is inert in practically all the usual vehicles and possesses the property, unique among inert light-coloured pigments, of absorbing practically 100 per cent. of incident ultra-violet light. Like carbon black, therefore, it affords a very durable film and, moreover, exerts an exceptionally high protective action on tints. It possesses the further advantage of high brightness.

Concurrent tests, under severe conditions, demonstrated the superiority of lead titanate paint over a typical "lead" paint (white lead 60 per cent., zinc oxide 30 per cent., extender 10 per cent.). The white lead paint deteriorated rapidly and failed completely after 14 months, but the lead titanate paint film was perfectly sound after three years.

This pigment, in addition to affording high durability and retention of tint and gloss, shows much promise as a rust inhibitor.

Tests on Pigments for Colouring Concrete.—A short account of some interesting tests on the production of coloured concretes for use in parks for pathways, seats, etc., has been given by A. H. Garnsey, the City Engineer of Sydney (*J. Instn. Munic. Cty. Engrs.*, 1936, **62**, 26). The pigments used were tested for colouring power, resistance to fading and to attack by alkalies, effect on the soundness and strength of the cement, solubility in water, fineness, volatile matter, organic matter; and the quantities of oxides of iron, manganese, chromium, calcium sulphate and Prussian blue were determined by analysis.

Trial mixtures were made with various pigments, shielded from direct sunlight and exposed for seven days. It was found that mineral oxides were the only pigments which did not fade; organic pigments, especially blacks, faded considerably. The intensity of the colour produced was found to depend as much upon the fineness of the pigment as upon the shade of the colour itself.

Seats were made with a 3: 2: 1 (coarse aggregate: sand: cement) mixture coloured with chrome green and black to the extent of 8·75 per cent. and 6 per cent. respectively of the weight of the cement. Slabs for pathways were constructed in two layers, the base course being a 4: 2: 1 concrete mixture containing gravel $\frac{5}{16}$ in. in diameter for coarse aggregate, with a topping, placed immediately after the base course, containing 10·6 per cent. brown oxide in a 2: 2: 1 mixture. The coarse aggregate in the topping consisted of $\frac{1}{8}$ in. screenings freed from dust, Botany sand being used for the fine aggregate.

A white efflorescence of calcium hydroxide and carbonate

which spoilt the appearance of the slabs was noticed in the first tests. This was prevented by reducing the mixing water to the minimum in both the topping and base course. This efflorescence was also produced after excessive working of the top course or faulty curing.

It was also found that care was necessary in the selection of a suitably coloured and clean aggregate and that only the lightest-coloured portland cements could be used.

RECENT RESEARCH ON EMPIRE PRODUCTS

A Record of Work conducted by Government Technical Departments Overseas

AGRICULTURE

Insect Pests

Locusts

Nigeria.—In his report for the period July-December 1935, Mr. J. D. Golding, Senior Entomologist, Department of Agriculture, Nigeria, states that during December an examination was made of marshes in the Numan Division of Adamawa and the Dikwa Division of Bornu. The principal object of this work was to determine whether the red locust (*Nomadacris septemfasciata* Serv.) occurs in the area to the south and south-west of Chad. In the past several reports from Adamawa referred to the red locust, which was said to be well known to the local natives. Not a single specimen of *Nomadacris* was seen and it was established that Adamawan reports, almost certainly, refer to the grasshopper *Phymateus karschi* Bol.

In October 1934 Gwynn found *Nomadacris* in four localities in the Dikwa Division to the east and north-east of Dikwa Town. Most of the locusts were in the tall grass, *Sorghum* sp. aff. *aethiopicum* Rupr., growing in inundated "black cotton soil." One of these areas was examined on December 20, 1935 and no red locusts were found. Almost all the grass was already dry and two bush fires had destroyed large areas of the dry Sorghum. By April nearly all the Sorghum is burnt off, leaving only bare soil, so it is difficult to believe that these areas can be of importance as habitats of *Nomadacris*.

The eastern fringe of the Yedseram marshes (near Lake Chad) was examined and no *Nomadacris* were found. In the future it is proposed to carry out an annual patrol of the southern section of the Chad shore. If it is found that the red locusts are beginning to form swarms arrangements will be made for an anti-locust campaign.

Termites

Ceylon.—Mr. F. P. Jepson, in his report on the work of the Entomological Division, Department of Agriculture, for 1935, records that the breeding of termites in captivity, in order to ascertain their habits and life-cycles, has been continued by Mr. M. P. D. Pinto. Winged adults of *Neotermes militaris*, the common species infesting tea in the up-country districts, were produced towards the close of the year from a colony founded 8½ years ago by a winged pair. Previously the same result has been obtained in the case of another colony in 7½ years.

Observations on the bionomics of dry-wood termites have been continued, and in the case of two colonies of *Planocryptotermes primus*, a widespread species which infests building woodwork, winged adults appeared during the year. These colonies were raised from eggs laid by neoteinic (wingless) adults six years ago. A colony of *Cryptotermes primus*, formed by a winged pair 6½ years ago, is still thriving. Winged adults appeared in this colony last year.

Tests of building materials, reputed to possess termite repellent properties, have been continued. A patent insulating wallboard fabric of British manufacture, received for test some time ago, although highly resistant to the attacks of subterranean termites, is not entirely immune, some slight degree of damage being apparent during the course of the test. It appears, however, to repel the attacks of dry-wood termites and is fatal to them when provided as food.

A sample of timber, impregnated with a proprietary preparation claimed to possess termite repellent properties and which has been under test for the Public Works Department during a period of 18 months, has been extensively attacked by subterranean termites (*Cyclotermes redemanni*).

Another test which is being conducted for the Public Works Department relates to samples of timber which have been treated with certain paints which are claimed also to possess termite repellent qualities. In this case, so far as the test has progressed, the claim would appear to be a good one, as, after a period of 14 months, the samples are still intact while the untreated controls have suffered severe injury.

A sample of timber treated with a rubber distillate solution has resisted attack by *Cyclotermes redemanni* during the 2½ years of the test, which has been carried out at the request of the Rubber Research Scheme of Ceylon.

Beverages

Cacao

Nigeria.—The half-yearly report of the Botanical Section, Department of Agriculture, Southern Provinces, Nigeria, for

the period July-December 1935, contains the following brief outline, by Mr. O. J. Voelcker, of the cacao selection and breeding work that has been carried out during the past five years.

During 1931 the individually recorded yields commenced in 1921 on some 1,500 trees were analysed. As a result 49 yellow pod Forastero trees were marked for detailed study. This study was devoted to each tree at each three-weekly harvest throughout 12 months, and the data obtained were used to convert the records of numbers of pods to weight of wet beans. During the year pollination experiments were carried out which demonstrated the ease with which this type of cacao will set fruit.

In 1932 flowers were self-fertilised on what were considered to be ten of the best trees in the preliminary selection. These were planted in baskets at Ibadan, and in nursery beds at Owena, and were planted out during the rains of 1933. The Ibadan planting, after rather heavy supplying, is now considered to be reasonably well established. The Owena planting suffered very heavy losses due to insufficient shade and nursery bed transplanting and was abandoned. It may here be mentioned that the self-fertilised pods ripen at the beginning of the dry season and, in quantity, at no other time. Thus the seed has to be planted in nurseries or in baskets. Experience has shown that the seedlings sown in nursery beds are too large for safe transplanting by the following June, especially if large numbers have to be handled. Hence basket planting is now invariably adopted.

In 1933 the selections were increased to 17 and self-fertilised pods were obtained for planting a new farm, financed by the Ibadan Native Administration at Ina, near Ibadan. Unfortunately, these were again planted in nursery beds as opposed to baskets and about 50 per cent. of the stands died during the dry season following transplanting.

In 1934 self-fertilised pods from the selections were obtained and planted in baskets at Owena for replanting the farm and at Ina for supplying. A number of crosses between selections were also made and sown at Owena and Ibadan. Ten selections were each budded on to 20 known stocks at Ibadan.

In 1935 Owena was replanted, Ina supplied and the crossed versus selfed experiments laid down at Ibadan and Owena. At all stations the outlook is promising, though a number of deaths will occur during the present and following dry seasons.

The present position with regard to these selections is therefore as follows :—

At Ibadan

400 stands planted out in 1933.	Yield inheritance.
200 „ „ „ 1933 and budded in 1934.	Clonal multiplication of selections.
400 stands planted out in 1935.	Crossed versus selfed.

At Owena

400 stands planted out in 1935.	Crossed versus selfed.
3,296 „ „ „ 1935.	Yield inheritance. Spacing experiment.

At Ina

8,352 stands planted out in 1934 heavily supplied 1935.	Yield inheritance. Spacing experiment. Shade experiment.

The object of this work is to find out which selected parent tree gives the best seminal offspring under varying conditions; to have available small budded plots of each selection and eventually to distribute seed from the budded plot of the proved selection. Thus Nigeria is relying on the future distribution of seed and not of vegetatively reproduced plants. At the same time the farms at Ina and Owena will provide much needed data on better methods of growing cacao.

Breeding for Light-coloured Beans.—Between 1914 and 1917 a few very small plots of cacao were planted at Moor Plantation with seed from selected pods collected from various West African sources. An analysis of the beans from these trees disclosed the fact that a few were light coloured. An attempt was made to obtain selfed or crossed pods from the trees which gave these light-coloured beans. Although considerable difficulty was experienced in getting the flowers to set fruit, yet a few did so. The top of each seed from these pods was cut off and the colour examined. The light-coloured ones were planted and they germinated without difficulty. In 1935, 45 such seedlings were planted out. Work on cotyledon colour in kola confidently leads to the expectation that cacao trees breeding true to white-coloured beans may within one or two generations be obtained. But, unfortunately, the light-coloured beans do not necessarily have the large plump size of Criollo cacao.

Other Experimental Work.—While much of the incidental work on cacao has been undertaken for immediate practical purposes, the following aspects have received attention:—

(*a*) The history of pods from the time of fertilisation to harvest, with special reference to pod shedding. ("A Study of Controlled Pollination in Cacao, *Theobroma Cacao*," *Bull. Agric. Dep., Nigeria*, No. XI, 1932.)

(*b*) The correlation of weight of bean and date of harvesting (this BULLETIN, 1935, 33, 64).

(*c*) The fermentation of unripe cacao, which led to the surprising result that a satisfactory product could be obtained.

(*d*) Relation between rate of drying fermented cacao and skin shrivelling (this BULLETIN, 1935, 33, 360).

(*e*) Growth measurements of selfed and crossed seedlings. The results are not yet ready for publication, but there appears to be no significant difference between these.

(*f*) In conjunction with the Chemical Section, the butter fat content of cacao beans is being explored.

(*g*) Examination of the ratio of number of pods to weight of pods to weight of wet beans. (Unpublished.)

Mr. J. D. Golding reports that on two occasions in November *Araecerus fasciculatus* de Geer. was found infesting stored cacao beans; in each case the cacao had been stored for a very long period. This is the first time that Mr. Golding has found this pest attacking stored cacao.

Coffee

Ceylon.—According to the report of the Entomological Division, Department of Agriculture, for 1935, a disturbing discovery during the year was the occurrence of the notorious coffee berry borer (*Stephanoderes hampei*) in the Balangoda district. The pest is a serious menace to coffee cultivation in certain African and Eastern countries, but it was not previously known to occur in Ceylon. How and when it gained admittance to the Island is not known. Towards the close of the year the insect was declared a pest under the Plant Protection Ordinance No. 10 of 1924. The regulations which are to be prescribed by law for its control are as follows: (*a*) The prohibition of the importation of coffee plants and seeds (other than dried or roasted beans or ground coffee for consumption) except with the permission of the Director of Agriculture; (*b*) the prohibition of the removal of coffee plants and seeds from infested areas to or through any area which is not infested; (*c*) the collection and destruction by fire of coffee berries and seeds attacked by the beetle and (*d*) the pruning, in an infested area, of coffee trees as may be required by the Director of Agriculture and the burning of all prunings together with all fallen berries and rejected beans, which are liable to be attacked by the borer.

So far as can be ascertained from a preliminary survey, the pest is at present confined to the Ratnapura District of the Sabaragamuwa Province and the Kosgama region of the Colombo District. The incidence of the pest was most

marked in the Balangoda area and a campaign was instituted during the year with the object of eradicating it from this area. Messrs. M. P. D. Pinto and B. A. Pereira were on special duty in the area in connexion with this campaign, co-operating with the local Agricultural Instructor. Over 1,500 gardens in this area were visited and over 30,000 coffee plants have been pruned and their berries destroyed. Mr. F. P. Jepson, Officiating Entomologist, records the appreciation of the Department of the assistance rendered by the Chief Headman of Balangoda and his officers in the performance of this work.

Life history studies of the insect were conducted by Mr. M. P. D. Pinto. They have shown that under laboratory conditions at Peradeniya the whole life-cycle of the beetle from egg to adult is completed in about a month. The female beetle selects ripe, or nearly ripe, coffee berries for breeding, entering in or near the depression on the free end of the berry by boring a small circular hole. The eggs, which are oval and milky white, are then laid in the seed and hatch in six days. The larvæ are full-grown in about 18 days and, following a pre-pupal period of two days, change to pupæ, which give rise to the adult beetles in five days. The female beetle lays approximately 50 eggs during her life, usually at the rate of 2 per diem, but several days may pass without oviposition. The interval between emergence of the female and oviposition is a variable one and may be as short as five days and as long as 20 days. The female beetles have been kept alive in the insectary for eight weeks. They are more numerous than males and larger in size.

Cereals

Rice

Ceylon.—The report of the Entomological Division of the Department of Agriculture for 1935 contains the following interesting account of the measures adopted to deal with a serious outbreak of the paddy swarming caterpillar (*Spodoptera mauritia*), which occurred in the centre of a 70-acre block of paddy near Katugastota during October, the attacked area being about 15 acres in extent.

The fields concerned were first flooded to as great a depth as the bunds would permit, causing the caterpillars to ascend to the tops of the plants and preventing them from spreading to the surrounding unattacked area. The next step was to spray a solution of kerosene and crude oil, in equal parts, on to the surface of the water, care being taken to avoid the solution coming in contact with the foliage of the plants. A continuous film of oil was thus rapidly formed on the surface

of the water. Men then entered the fields and lightly brushed the plants with bundles of twigs tied together to form brooms and the insects were thus swept from the plants to the film of oil below. On the following day the caterpillars which had been dislodged were found to be dead and those which had been missed in the first sweeping were brushed off. The water in the fields was then completely drained off, carrying the oil with it. In cases where attacked fields lend themselves to flooding to a suitable depth this method of control can be applied with success.

The same report deals also with another pest of rice, the paddy stem-fly (*Atherigona* sp.). Towards the end of January reports were received from parts of the Central and Uva Provinces that extensive areas of seedling paddy were being partially destroyed and, in some cases entirely ruined, by an insect pest which proved to be a small Anthomyid fly. Seedlings were attacked within a week after germination and in areas where there was a shortage of water the attacked plants were unable to tiller vigorously and in many areas at least 50 per cent. of the seedlings were killed.

The maggot apparently causes primary damage by cutting through the young central shoot, feeding inside the decaying portion and pupating inside the stem, usually near the base of the plant. The life-cycle occupies about two weeks and the flies, in areas where paddy is sown at intervals of a few days, are able to attack successive areas of young seedlings soon after germination. The pest was most destructive in areas where sowing had been delayed owing to the failure of the rains. Later, when more water became available, the attacked plants started to tiller vigorously and were able to throw off the attack. Reports on the presence, or otherwise, of the pest in the various districts indicated that it had been observed in the North Central and Eastern Provinces in addition to those mentioned above.

Root Crops

Cassava

Nigeria.—In connection with the mosaic disease of cassava in Nigeria, reference was made in this Bulletin, 1935, **33**, 367, to the fact that this virus disease is probably carried by the white fly, *Bemisia nigeriensis* Corbett. Mr. J. D. Golding, Senior Entomologist, Department of Agriculture, in his report for July-December 1935, states that during this period further experiments in which adult white flies were transferred from diseased plants to caged healthy plants have been carried out. Positive results were obtained in seven experiments and there is now no doubt that *Bemisia nigeriensis* Corbett is a

vector of mosaic. Experiments in which *Bemisia* adults from mosaicked cassava were introduced into cages containing Ceara rubber and a weed, *Euphorbia heterophylla*, respectively, gave negative results.

The incidence of adult and immature *Bemisia* on 19 varieties of cassava was studied. It was found that both adults and nymphs were about $2\frac{1}{3}$ times as numerous on ten varieties with from 70 to 100 per cent. of the plants mosaicked as they were on 9 varieties with from 0 to 20 per cent. of the plants mosaicked.

Fruits

Citrus

Ceylon.—The report of Mr. L. S. Bertus, Acting Mycologist, for 1935, records an interesting case of collar rot of young imported grafted orange plants caused by *Sclerotium Rolfsii*. This is the first occurrence of this disease on citrus in Ceylon. In this instance it is suspected that the fungus spread to the orange plants from decaying vegetable matter used in the holes or as a mulch. One affected graft appeared to be a vigorous plant and was just over two centimetres in diameter at the collar. The bark along one side of the stock and at the collar had decayed and there was an abundance of white strands of mycelium about the decayed portions. The mycelial strands had grown down the greater part of the tap root and of some of the lateral roots. Typical brown shiny sclerotia were produced on the masses of the mycelium at the collar and on the roots.

A disease of grapefruit trees affecting the bark of the trunk and larger branches sometimes accompanied by exudation of gum to the surface was of frequent occurrence during the long spell of dry weather. The first indication is a thin, longitudinal crack in the bark which gradually opens to expose the wood. The open wound heals over in time. In some cases *Diplodia* sp. accompanies the crack and the mycelium of the fungus enters the wood giving it a greyish tint and kills back the branch. It is thought that defoliation as a result of drought conditions leads to exposure and consequent scorching of the branches by the sun which causes these wounds. Improving the protection of the plants from sun and wind and mulching them well throughout the dry season will do much to remedy any deficiencies in this respect. Shaving back the affected tissues to sound wood, painting over the wood with a disinfectant, such as a 20 per cent. solution of Brunolinum or Carbolineum, and then tarring the wound has been found effective against this type of canker.

Citrus canker is undoubtedly the most serious disease of

grapefruit and lime in Ceylon. When lime is severely affected with canker on the stems it is most desirable that the trees should be uprooted and destroyed, as experience has shown that the eradication of the disease from the trees is a very tedious and expensive operation; further the diseased lime trees always remain a potential danger to grapefruit should they happen to be planted in the neighbourhood. It is thought that grapefruit and lime should not be grown as a mixed crop unless steps are taken from an early date to keep citrus canker under control. The drought experienced during the first nine months of the year and during the latter months of 1934 has helped to control citrus canker to a large extent. With judicious pruning of unthrifty branches, cutting off diebacks, regular picking of cankered leaves and spraying at each burst of new foliage with a combined insecticide and fungicide consisting of colloidal sulphur, nicotine sulphate and water with the addition of soft soap as a spreader citrus canker can be kept under reasonable control. This spray fluid has been found effective, not only against citrus canker, but it also helps to ward off insect pests, pink disease and mildew. It must be borne in mind that for the spray fluid to be effective both surfaces of the leaf should be thoroughly sprayed.

In the control measures taken to deal with citrus canker at the Nalanda Experiment Station the following quantities of materials were used for spraying 164 grapefruit plants ranging from 1½ to 5 years old: 30 oz. of colloidal sulphur, 30 oz. of soft soap and 7½ oz. of nicotine sulphate, in 30 gals. of water.

Nigeria.—The half-yearly report of the Botanical Section, Department of Agriculture, Southern Provinces, Nigeria, for the period July-December 1935, contains the following account, by Mr. J. West, of investigations carried out on scab of citrus.

As mentioned in a previous report (this BULLETIN, 1935, **33**, 369), a successful control of scab disease, *Sporotrichum citri*, on sour orange seedlings by shading had been obtained at Ibadan from November 1934 to May 1935. It was pointed out, however, that this period included the drier portions of the year, and that shade alone might not prove sufficient during the height of the rains.

With the advent of the full rains in June 1935, scab rapidly assumed serious proportions on all unshaded sour oranges. The disease continued to be equally severe until the appearance of the short dry season in August. From then onwards it gradually died down.

In view of the successful preliminary experiments, shade had been adopted as the standard control measure for all new beds. Throughout the rains seedlings were being transplanted

into beds which had previously been shaded with palm leaves at a height of about 5 ft. It was found necessary to augment the palm leaves with banana leaves in order to make the shade effective.

The 1935 wet season, though normal as regards total rainfall, had an abnormal number of wet days. During this period, shade which was sufficiently dense to control the spread of scab equally checked any growth on the part of the sour orange seedlings. It must be remembered that, for the sake of economy and convenience, the policy has been to expand the present nursery instead of laying out new nurseries in other parts of the plantation. Consequently the original sources of infection are extensive.

In August a number of unshaded beds, furthest removed from the old beds, were filled with transplants, and the resulting growth was good, without there being a serious scab infestation. From September onwards various methods of shade thinning and shade removal have been tried out. In general, they have brought about satisfactory growth responses without inducing scab outbreaks.

During the rains it was found that neither frequent applications of small amounts of ammonium sulphate nor the burying of trash in the beds before planting would induce growth under the shade.

From these results it appears that, at Ibadan, the most important step will be the establishment of new nurseries at some distance from the present one. The management of the shade appears to involve density at that period of the year when scab is active, and thinning or removal as soon as possible in order to bring on the sour orange seedlings.

Oil Seeds

Coconuts

Ceylon.—In the report of the Mycologist, Department of Agriculture, for 1934, it was recorded that during the latter part of that year larvæ of the coconut beetle (*Oryctes rhinoceros*) were found naturally infected and killed by the green muscardine fungus (*Metarrhizium anisopliae*) in Kochchikadde at an elevation a little above sea-level (this Bulletin, 1935, **33**, 228). According to the report of Mr. L. S. Bertus, Acting Mycologist for 1935, as larvæ living under natural conditions were readily infected by artificial inoculations at an elevation of about 1,500 ft., experiments were made to ascertain whether the fungus could be made to infect larvæ at lower elevations.

Traps were prepared on the lines described in the previous report on a coconut estate in the Kurunegala district (elevation about 500 ft) with a view to attracting the coconut beetle

to lay its eggs in such traps. The traps proved attractive and larvæ of the coconut beetle were found in them after about three months; they were then inoculated by mixing the fungus grown on boiled rice with the surface soil. When the traps were examined after four weeks the fungus was found to have attacked and killed all the larvæ. The larvæ in the control traps were free from infection during this period. An experiment was also made by inoculating a trap by introducing soil into it taken from a trap which had been previously inoculated seven weeks earlier. The larvæ in this trap also were attacked and killed.

Experience has shown that it is necessary to keep the inoculated traps fairly moist; if the traps became too dry or saturated with too much moisture less deaths occur among the larvæ. The results of the experiments have indicated that the fungus can be introduced into traps at an elevation of 500 ft. to cause successful infection.

Oil Palm

Nigeria.—The following account of work carried out on the selection of oil palms by Mr. E. H. G. Smith is contained in the report of the Botanical Section, Department of Agriculture, Southern Provinces, Nigeria, for the period July-December 1935.

Details of the areas planted at the various experimental stations with oil palm selections were given in this BULLETIN, 1935, **33**, 73. During the past year attention has been paid to multiplication plots for the production of improved seed for the Nigerian farmer. Many years must elapse before anything in the nature of pure oil palm strains can be evolved. But in the meantime seed can be taken from palms grown from self-fertilised seed and whose parent trees have passed a preliminary selection test based on yield and fruit analysis.

The thick-shell fruit forms of the oil palm very largely breed true to the general parental form, whether subject to cross- or self-pollination, but the thin-shell fruit forms appear to give only 25 per cent. (or rather more) of progeny true to the parental form when cross-pollinated and in the neighbourhood of 50 per cent. when self-pollinated. The actual proportion of thin-shell progeny given by a thin-shell palm which is subject to natural cross-pollination, appears to depend on the proportion of thin- to thick-shell palms with which it is surrounded. That is, upon the chances of its flowers being crossed with the pollen of thin- or thick-shell palms. Generally speaking, the oil palm is only self-pollinated by artificial agencies. The chances are against the flowers of male and female inflorescences on a palm being mature at the same

time, though such an instance is by no means an impossibility; while the male and female flowers of mixed (bisexual) inflorescences mature at different times. It follows, therefore, that to obtain the highest possible proportion of thin-shell palms in the new native farmer's oil palm plantations now being established, thin-shell parent palms must be artificially self-fertilised, or permitted to cross among each other. The latter is the only practical alternative for a bulk seed supply scheme.

During 1935 two isolated plots of thin-shell palms were planted out. One at Benin Experimental Station of ten acres was used for the ordinary thin-shell fruit form. The other at Onitsha of five acres was utilised for the green-fruited thin-shell form. The minimum distance of isolation from other palms is some 300 yds. at Benin and just over 100 yds. at Onitsha. As these plots come into bearing all off-type palms will be cut out and further supplies will be planted to fill the vacancies. Within each of the blocks one oil palm fruit form only will be maintained and the seed from palms which have crossed only with palms of similar form will be available for the native farmer's plantations. In later years it will be possible to improve the seed supply a degree further by also cutting out the poorer-yielding palms. These blocks are in effect a form of mass selection for improved oil palm seed and the procedure adopted is the only one that is practical at the present time.

Tung Oil

Ceylon.—Mr. L. S. Bertus, Acting Mycologist, in his report on the work of the Mycological Division, Department of Agriculture, for 1935, states that brown root disease (*Fomes noxius*) has been recorded for the first time on tung oil (*Aleurites montana*) in Ceylon. The fungus has probably spread to the trees from jungle stumps. *Fomes lignosus*, *Ustulina zonata* and a species of *Poria*, probably *P. hypolateritia*, have been previously recorded on *A. montana*. This brings up the question of eradication of stumps when it is intended to plant *Aleurites* on old *Hevea* or tea land. As long as *Hevea* or tea stumps are left behind on land newly planted with *Aleurites montana* root diseases should be expected to occur. Jungle stumps may also serve as sources of infection.

Small tung-oil plants were received during the year which were killed by a rot at the collar. This form of collar-rot in small plants usually occurs in bright sunny weather when plants are insufficiently shaded. The sun heats the soil and the tender cortical tissues are scorched and killed by the overheated soil. The trouble is usually prevented by shading the plants.

A preliminary experiment was carried out to see if zinc

sulphate would have an ameliorative effect on tung-oil trees which were suffering from a condition similar to that known as "bronzing" in America (see this BULLETIN, 1935, **33**, 468). Twelve trees were treated with ½ lb. of zinc sulphate each, applied to the soil in solution. Up to the present the treatment has proved ineffective.

TOBACCO

Nigeria.—The report of the Botanical Section, Department of Agriculture, Southern Provinces, Nigeria, for July-December 1935, contains the following account, by Mr. J. West, of investigations on leaf curl in tobacco.

Leaf curl, a virus disease in tobacco, was first observed in Southern Nigeria in 1923 in some experimental plots at Ilorin. Jones and Mason (*Ann. Bot.*, 1926, **40**, 762) stated that they frequently found the symptoms on tobacco plants in the south-western provinces of Oyo and Abeokuta. An isolated case was reported from Northern Nigeria in 1935. Recent observations suggest that, while leaf curl can be found on much of the native-grown tobacco, the percentage of infection is usually very low.

In the south-western provinces the rains generally occur from April to October, with, frequently, a short break in August. June, July and September are the wettest months, and the total annual precipitation is in the region of 50 in. Normally the Yoruba farmer transplants his tobacco seedlings to the field in August, so that the crop begins to ripen as the dry season approaches. Under these conditions the incidence of leaf curl is slight.

In 1935 an attempt was made at Ipetu to grow two crops of tobacco, one being planted out early in June, and the second one in late August and September. The early crop was almost entirely ruined by leaf curl, and infection was carried over to the late crop, though to a lesser degree. At Ogbomosho in the same year only a late crop was tried, transplanting to the field beginning about the end of August. This crop had under 1 per cent. of leaf curl infestation.

Experiments carried out at Ibadan in co-operation with Mr. F. D. Golding, Senior Entomologist of the Department, have shown that a species of white fly (*Aleurodidae*) is capable of transmitting leaf curl in Nigeria. This result agrees with the findings of Storey (*Rhodesia Agric. J.*, 1932, **29**, 186) and Hopkins (*ibid.*, p. 680) in East Africa.

Observations in the field showed that the white fly population at Ogbomosho diminished rapidly after July, and by the end of August had become practically non-existent on the tobacco. The nurseries, which were sown during June, were heavily infested with white fly throughout July, but in only

two beds were any infected seedlings found, and these were rogued out. At Ipetu, where the rainfall is a little heavier, white fly still existed somewhat sporadically in late September, and this fact, coupled with nursery bed infection from the early crop, leads to the spread of leaf curl through the late crop.

The control of leaf curl in the south-western provinces appears to be entirely practicable, provided a late planted crop is attempted, as is the native custom. Nursery bed infection is reduced to a minimum, and white fly in the field is largely avoided. When this is coupled with the roguing out of any infected plants, at or after transplanting, the crop should be almost completely healthy.

In East Africa both Storey and Hopkins (*loc. cit.*) mention a species of *Vernonia* (Compositæ) as being an alternate host. In the south-western provinces *Vernonia amygdalina* occurs commonly as a shrub in the bush. Cases have been found in which the leaves showed the dark green coloration of the veins and the production of enations which are typical of leaf curl on tobacco. It has not yet been proved whether this is leaf curl, but the white fly do not appear normally to relish *V. amygdalina* as a host in the field.

Resins

Lac

Ceylon.—According to Mr. F. P. Jepson's report on the work of the Entomological Division of the Department of Agriculture for 1935, the progress of lac cultivation in Ceylon has, unfortunately, received a severe setback. The continued drought affected adversely the growth of inoculated trees and the insects were unable to establish themselves on the dried-up shoots. Parasites and predators have played their part in causing a reduction in the small numbers of insects which were able to survive.

In addition to these difficulties the behaviour of the insects themselves has been unusual. Their life-history, possibly owing to the unusual weather conditions, has been irregular and swarming has taken place at shorter intervals than normally. The shortening of the life-cycle has been accompanied by a corresponding decrease in the amount of brood lac formed. Most of the brood material which had been raised in Ceylon has been lost and it has become necessary to arrange for the importation of further brood material.

The advisability of persevering with the attempted establishment of masan or "ber" lac in Ceylon is questionable, as the quality of this product is very much inferior to that of kôn or "kusum" lac. The latter still commands a good price in London in spite of accumulated stocks and there is a better prospect of disposing of good kusum seed lac than of doing

so after its conversion into shellac. It would appear advisable, therefore, to concentrate upon the establishment of kusum lac in a few centres where climatic conditions are likely to be most favourable to its development. Such centres should permit of regular and frequent inspections being made to follow the development of the insects and they should not be so numerous as to make the simultaneous harvesting of the broods and reinoculation of further host trees an impossible undertaking for the staff now available.

When Indian lac has been established in Ceylon, its adaptation to local climatic conditions studied and the most suitable localities for developing the enterprise finally decided upon, steps can then be taken to distribute the brood material from the various centres in which it has been established.

MINERAL RESOURCES

NIGERIA

The Imperial Institute has received the following statement from the Director regarding the work carried out by the Geological Survey of Nigeria during the second six months of 1935.

Gold.—During the period no further geological work has been carried out in the goldfield owing to the absence of the officer concerned on leave. Investigations will be recommenced early in the new year. The monthly output has been maintained and the total yield for 1935 reached 38,962 oz.

Water Supplies.—Shaft sinking for water has been carried on steadily in the Northern Provinces, resulting in 75 wells being completed for this half-year. This brings the total number of wells constructed during 1935 to 155 for a footage of approximately 20,000 ft. sunk.

There have been no departures from the approved programmes in the various Emirates and no difficulties have been experienced other than those normal to this type of work.

Wherever tube wells have been installed they have proved very popular, but development by this method has been hampered owing to the difficulty of obtaining pumps which will withstand both rough and continuous usage. The matter has been discussed at length with the Crown Agents and the makers with a view to evolving a design more suited to the needs of this country.

A drilling programme extending over five years has now been approved by Government and the equipment together with the driller are expected to arrive in Nigeria early in the new year. It is proposed to commence operations at Otta, about 23 miles from Lagos and when work has been completed in this area to move the drill to the Northern Provinces.

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PLANT AND ANIMAL PRODUCTS

AGRICULTURE

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Flotation of Langbeinite from the Potash Field of New Mexico and Texas. By F. D. DeVaney and S. R. B. Cooke. *Inform. Circ. No.* 3300, *U.S. Bur. Mines*. Pp. 4, 10½ × 8. (Washington, D.C.: Superintendent of Documents, Government Printing Office, 1936.)

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Anhydrous Sodium Sulphate from Saline Deposits or Brines, by a Four-stage Process. By J. E. Conley and E. P. Partridge. *Rep. Invest. No.* 3299, *U.S. Bur. Mines*. Pp. 18, 10½ × 8. (Washington, D.C.: Superintendent of Documents, Government Printing Office, 1936.)

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The Zirconia Deposits of Brazil. By A. Cownley Slater. *Sands, Clays and Min.*, 1936, **2**, No. 4, 103-107.

NOTICES OF RECENT LITERATURE

Books for review should be addressed to "The Editor," Bulletin of the Imperial Institute, South Kensington, London, S.W.7.

UGANDA. By H. B. Thomas, O.B.E., and Robert Scott. Pp. xx + 559, $8\frac{1}{2} \times 5\frac{1}{2}$. (Oxford: The University Press; London: Humphrey Milford, 1935.) Price 15*s*.

This volume, by officers of the local Civil Service, though compiled largely from official records and published by the authority of the Government of Uganda, is not actually an official publication. It is, however, furnished with an Introduction by the present Governor, Sir Bernard Bourdillon, and also contains a Foreword by Lord Lugard, who was intimately concerned in the arrangements by which the country was taken under British protection in the last decade of the nineteenth century. The events leading up to this important step and the subsequent political developments are traced in a chapter entitled "Historical Retrospect," which, though extremely interesting in itself and important for readers who desire information on this aspect of the subject, does not indicate the main purpose of the book, which is to describe the country as it is at the present time—one of the most orderly and prosperous territories in tropical Africa, self-supporting financially for the last twenty years and showing very great promise for the future.

The wide field covered and the systematic arrangement of the contents of the volume may be indicated by the following titles of some of the principal sections: Situation, Natural Features and Climate: Geological Background: The Native Peoples of Uganda: Cotton and the Cotton Industry: Forests: Zoology: Minerals and Mining: Native Life: Education: Trade and Commerce: The European and Asiatic Communities. Following on these and other sections of much interest are several providing information of special use to visitors, not only regarding transport, accommodation, outfit, etc., but also on game and hunting (including a description of the principal animals and birds concerned), fishing, golf and other recreations, excursions and so on. The magnificent scenery of many parts of the country is well described and this and other features of interest are illustrated by photographs. Several useful maps are also furnished. At the end of the volume there is a full bibliography and list of current maps of the country, followed by appendixes giving information on revenue, import and export trade, licence fees, meteorological data, route mileages, etc.

The volume may thus be regarded from some points of view as a Handbook, but although many of the details which it contains will become out of date as time goes on and necessitate a new edition, a large proportion of the matter is of permanent value and forms, in effect, a general treatise on the Protectorate. The book is one on which all concerned in its preparation, including the Oxford University Press, can be sincerely congratulated, and it should long remain a standard work on the diversified region with which it deals.

KENYA: CONTRASTS AND PROBLEMS. By L. S. B. Leakey, M.A., Ph.D., F.S.A., F.R.A.I. Pp. xiii + 189, 7½ × 5. (London: Methuen & Co., Ltd., 1936.) Price 7*s.* 6*d.*

Although this volume is of modest dimensions, it may be described as an important and instructive treatise on Kenya which should be studied by all connected with the Colony, whether in the Government service or concerned with the planting industry, missionary and educational enterprise, or scientific investigation. The author is sufficiently well known to render the book worthy of notice as coming from his pen, but it is of additional value owing to the fact that Dr. Leakey was himself "born and bred in Kenya" and has spent the greater part of his life there. To quote from his Preface: "As the son of a missionary, I have always been intensely interested in the problems which concern the welfare of the natives and my work has given me every opportunity to study those problems from the native point of view. I learnt the Kikuyu language as a child and it became almost my native tongue."

In the various chapters Dr. Leakey deals in a concise and interesting manner with the natural history of the country and its remarkable diversities of climate and physical character; the relations between the natives and the European settlers, missionaries and officials; and the problems of language, native education and social customs. In the course of the work he makes a number of comments and practical suggestions which clearly deserve the most careful attention in Kenya, and it may be said that this unpretentious book is one to be read and pondered over by all Europeans concerned with tropical colonies.

TROPISCHE UND SUBTROPISCHE WELTWIRTSCHAFTSPFLANZEN, IHRE GESCHICHTE, KULTUR UND VOLKSWIRTSCHAFTLICHE BEDEUTUNG. By Prof. Dr. Andreas Sprecher von Bernegg. III Teil, 2 Band: Kaffee und Guaraná. Pp. xi + 286, 10 × 6½. (Stuttgart: Verlag von Ferdinand Enke, 1934.) Price, paper cover, Rm. 21; bound, Rm. 23.

TROPISCHE UND SUBTROPISCHE WELTWIRTSCHAFTSPFLANZEN IHRE GESCHICHTE, KULTUR UND VOLKSWIRTSCHAFTLICHE BEDEUTUNG. By Prof. Dr. Andreas Sprecher von Bernegg. III Teil, 3 Band: Der Teestrauch und der Tee; Die Mate- oder Paraguay-teepflanze. Pp. xvi + 432, $9\frac{1}{2} \times 6\frac{1}{4}$. (Stuttgart: Verlag von Ferdinand Enke, 1936.) Price, paper cover, Rm. 31; bound, Rm. 33.

The author of this work, the two latest volumes of which are before us, spent many active years of his life in Java and Brazil and is well qualified by first-hand experience to deal with the four economic plants of which the volumes treat.

Following the general plan of the work each section contains accounts of the history of the plant concerned, its habitat and botany, the climatic and other conditions affecting its growth, its cultivation and chemistry, and the preparation and utilisation of the product, besides discussing yields, costs, profits and trade.

The first of the two volumes is almost entirely concerned with coffee, on which it is a mine of detailed information, and the second deals equally fully with tea and mate. Guaraná, a South American plant (*Paullinia Cupana*), the seeds of which are rich in caffeine, is less fully but quite adequately treated in eleven pages. Each volume has its own index and each section concludes with a bibliography. In addition, the sections on coffee, tea and mate have an interesting feature in the form of tables of numerical data; thus the table of "Teezahlen" consists of nearly a hundred items ranging from the limits of latitude between which the plant occurs naturally to the average life of a plantation and from the cubic capacity of a tea-chest to estimated world consumption.

The volumes should prove invaluable not only to planters and others whose interest is the production and marketing of the various commodities, but also as a work of reference in all libraries concerned with tropical and subtropical agricultural and economic products.

DER TEE IM BRITISCHEN WELTREICH. By Fritz Klopstock. Pp. 87, $8\frac{1}{4} \times 6$. (Berlin: H. S. Hermann-Büxenstein, G.m.b.H., 1936; obtainable from the author, Herr Doktor Fritz Klopstock, Berlin-Wilmersdorf, Kaiserallee 24.)

This is the author's dissertation for his doctor's degree in political science at the University of Berlin. It represents a considerable amount of painstaking work in collecting information from numerous sources, largely British, and presenting it in an ordered form as a connected whole. It deals with the production of tea both in the British Empire and outside it, its consumption in different countries, the rôle of London

in the tea markets of the world, trade tendencies and the problem of balancing production and consumption, the effects of restriction schemes and propaganda, and the probable course of events in the near future.

DIE OLBOHNE ODER SOJA. By Dr. Arnold Kornfeld. Pp. 32, $8\frac{1}{2} \times 5\frac{1}{2}$. (Hamburg: Tropenverlag Fr. W. Thaden.) Price Rm. 1·40.

This pamphlet contains in a convenient form a large amount of information useful to anyone interested in growing soya beans either in the tropics or in temperate climates.

It deals with the cultivation of the bean and conditions requisite for success, its diseases and pests and its use in rotation with other crops. The possibilities of the plant on the farm for green manure, fodder and ensilage are discussed, as well as the value of the seed and the parts its various products can play in industry and manufacture.

The author has made a study of numerous different varieties of soya bean and of the results of breeding trials, as a result of which he is able to recommend "tested" varieties according to the particular conditions under which the crop is to be grown and the uses to which it is to be put.

PERFUMES, COSMETICS AND SOAPS, WITH ESPECIAL REFERENCE TO SYNTHETICS. Volume I. Being a Dictionary of Raw Materials together with an Account of the Nomenclature of Synthetics. By William A. Poucher, Ph.C. Pp. x + 439, $8\frac{1}{2} \times 5\frac{1}{2}$. Fourth Edition. (London: Chapman & Hall, Ltd., 1936.) Price 25s.

Two previous editions of this treatise were reviewed in this BULLETIN (1923, **21**, 665 and 1926, **24**, 74). Originally issued in one volume, the work is now published in three volumes. The expansion has been found necessary owing to extensive alterations and additions which have been effected consequent upon the progress made in the perfumer's art and the introduction of many new perfumery materials. This volume is essentially a descriptive dictionary of the more important raw materials and miscellaneous products of interest for the perfumery and allied trades. Since the last edition, published in 1930, a further 45 pages have been added and there are ten extra illustrations, making 40 altogether.

The additional matter includes 17 essential oils, 68 synthetic aromatic chemicals and 32 cosmetic constituents. The essential oils new to this volume include Atlas cedarwood oil, grapefruit oil and Australian "tea-tree" oil. Some omissions are noted; for instance, no mention is made of Kenya cedarwood

oil (*Juniperus procera*) which has now an established market position. There are two appendices—one on chemical nomenclature, to assist those readers possessing little chemical knowledge and another on physical constants readily determined without the use of expensive apparatus. The book will continue to be invaluable to all interested in the perfume industry.

CHEMISTRY AND TECHNOLOGY OF WINES AND LIQUORS. By Karl M. Herstein, F.A.I.C., and Thomas C. Gregory. Pp. xii + 360, 9 × 6. (London: Chapman & Hall, Ltd, 1935.) Price 30*s*.

This is a book written by Americans and primarily for Americans. In the Old World wine making was an art long before science was "applied" to almost every field of production. In America, the industry is less than two hundred years old and has developed in very different circumstances. In particular, it suffered a temporary demoralisation during the period of prohibition, from which it emerged suddenly to find all the intensified resources of technology at hand to direct its fresh activities. To some extent, therefore, this book may fulfil its authors' hope that it will "in a sense serve to mark the end of an era and the beginning of a new one."

The first few chapters deal with the chemical nature of sugars and starches, cereal grains and other raw materials, malt, yeast, the principles of fermentation and distillation, types of stills, and other theoretical considerations. These are followed by others devoted to the manufacture of whiskey, brandy, rum, gin and other distilled spirits, wines of various types, cider and liqueurs. There is a section dealing with the analysis of alcoholic beverages, the laboratory processes described being the "Official and Tentative Methods" of the Association of Official Agricultural Chemists. Lastly, there is a chapter of "Statistics of the Liquor Industry" which relates wholly to the industry of the United States.

Perhaps the most fully-written chapter in the book is that on Whiskey Manufacture. This gives a historical outline of the subject, explains the distinction between pot still and patent still whiskeys and their characters, between Scotch and Irish and between British and American methods of manufacture, and discusses the principles of blending. It contains several figures showing the lay-out of plant for large-scale operations used in American practice. The artificial ageing of spirits by such means as catalytic oxidation, exposure to ultra-violet light, electrolysis and high tension discharge, is discussed in the part of this chapter headed "American Whiskey."

THE CHEMISTRY OF MILK. By W. L. Davies, Ph.D., D.Sc., F.I.C. Pp. xii + 522, $8\frac{1}{2} \times 5\frac{1}{2}$. (London: Chapman & Hall, Ltd., 1936.) Price 25s.

This work is the tenth of a series of monographs issued, under the editorship of Dr. E. Howard Tripp, with the purpose of focussing attention upon recent work or upon new aspects of old work.

The author has found it convenient to collect the large amount of material under five main headings and the scope of this work can be indicated best by a précis of the material to be found in each of these groups.

The first section deals with the composition of milk and includes information on the sources of milk, composition of milk from various species of mammals, classification of the constituents and special variations to be found in supply. Part II deals with the constituents of milk, such as milk-fat, milk-sugar, milk-proteins and the mineral constituents of milk. One chapter is devoted to milk-enzymes and another to minor constituents of milk such as milk-pigments, vitamins, heavy metals and gases. Over a hundred pages are given up to the physical chemistry of milk which is the subject of Part III. The phenomena of separation, churning, whipping, surface tension, frothing, viscosity, electrical conductivity, hydrogen-ion concentration and coagulation are all dealt with. The fourth section commences with the effect of heat and metals on milk and continues in natural sequence to the technology of milk condensing, dried milk and such products as malted milk and dried butter-milk. The last part of the book, which is devoted to a consideration of the nutritive value of the major constituents of milk, includes a well-written chapter on vitamins and ends with a discussion on the nutritive value of milk as a whole.

Numbered headings to each section in heavy type, together with adequate subject and author indexes, render reference to any subject a matter of ease, while those who wish to consult original papers will find over 1,400 references at their disposal. The author has undoubtedly succeeded in his attempt to gather together in a concise, ordered form, the results of all the relevant and reliable investigations on the chemistry of milk. Apart from its obvious value to the dairy chemist, the book should prove invaluable also to physiologists, nutritionists and members of the medical profession.

SOILS. THEIR ORIGIN, CONSTITUTION, AND CLASSIFICATION. By Gilbert Wooding Robinson, M.A. Pp. xvii + 442, $8\frac{1}{2} \times 5\frac{1}{2}$. Second Edition. (London: Thomas Murby & Co., 1936.) Price 20s.

The first edition of this work was reviewed in this BULLETIN (1932, **30**, 394), and the fact that a second edition

is needed in less than four years shows that it has met with appreciation.

In the new edition, a number of changes have been made, although the author has not attempted to cover the whole of the mass of work published since the previous edition was issued. The general arrangement remains much as before, but a number of ambiguous or obscure statements have been clarified. Parts of the book dealing with subjects in which there have been notable advances in concrete knowledge and in theories have been largely re-written, the changes occurring mainly in the sections concerned with Pedogenic Processes, the Clay Complex, Base Exchange, Soil-Moisture Relationships and Soil Classification. Additional examples have also been included in the chapters on the soil groups. In view of the recent publication of C. H. Wright's book on Soil Analysis (reviewed in this BULLETIN, 1934, **32**, 337) the appendix on Methods of Analysis has been omitted. A number of additional references to recent literature appear.

GETTING ACQUAINTED WITH MINERALS. By George Letchworth English. Pp. xi + 324, 9 × 6. (New York and London : McGraw-Hill Book Company, Inc., 1934.) Price 15s.

Though primarily intended for the beginner in the study of mineralogy, this book cannot fail to appeal to the general reader by reason of its excellent plates and while given in simple terms, the descriptions of the minerals form a good basis for a serious study of the science.

The first part of the book is devoted to consideration of those physical properties of minerals which have determinative value, such as hardness, habit, cleavage, fracture, streak, lustre and density and includes four chapters on elementary crystallography. The account of the use of the mercury-vapour lamp for producing fluorescence makes an attractive feature at the conclusion of this part.

In addition to accounts of the common minerals in the second part, in which the carbon group of minerals is dealt with at some length, the author has included a special section on rock-forming minerals, calculated to provide the geological background so essential to students of mineralogy. Part III deals with the commoner rocks of the earth's crust and further strengthens the link with geology.

Two appendices to the work give it added value, the first of these being a guide to the rapid identification of minerals based on purely physical properties ; and the second, a short pronouncing vocabulary of mineral names.

METALLIFEROUS MINE SURVEYING. By Frederick Winiberg. Pp. ix + 282, $8\frac{1}{2} \times 5\frac{1}{2}$. Second Edition. (London: Mining Publications, Ltd., 1935.) Price 15s.

This is a new and enlarged edition of the work which was first published some ten years ago and is of value both to the student and the metal mining engineer. In addition to accounts of the more ordinary procedure of mine surveying, the author ably reviews the trend of modern instrument design and describes two prominent micrometer-reading theodolites of the latest pattern and also equally advanced tacheometers. The chapter on astronomical observations should prove of great use to colonial workers whose operations necessarily include determinations of meridian, latitude and even time. Modern centering and co-planing devices which facilitate the connection of underground and surface surveys are dealt with and the importance of extreme accuracy in this work is rightly stressed. The instructions for carrying out observations with the various instruments are clearly given and the book is excellently illustrated.

HANDBOOK FOR PROSPECTORS. By M. W. von Bernewitz. Pp. vii + 372, $7\frac{1}{4} \times 5$. Third Edition. (London: McGraw-Hill Publishing Co., Ltd., 1935.) Price 18s.

Three editions of this well-known handbook for prospectors have been issued within the last ten years, only four years having elapsed since the issue of the second edition, which was published in 1931 and reviewed in this BULLETIN (1931, 29, 502).

The third edition differs from the second in that recent information regarding certain minerals has been added, sections on maps and mining laws are new, minor errors have been corrected and the whole of Part III re-arranged and expanded. The chapter on geophysics, which appeared in the second edition, has been deleted, since it is believed that the ordinary prospector is not likely to be expert enough to apply the detailed methods that are involved.

The work is designed primarily for the North American mining engineer and prospector, but should prove useful to all engaged in the search for minerals.

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ARTICLES

SCIENTIFIC ASPECTS OF CACAO FERMENTATION

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PART VI

VARIATIONS IN, AND ALTERNATIVES TO, FERMENTATION, AND THE PRODUCTION OF AROMA

THE PRODUCTION OF ACETIC ACID

No account of cacao fermentation would be complete without some discussion of the place occupied by acetic acid. Its production has been variously held to be essential, desirable, unavoidable and objectionable.

The planter accepts the development of acetic acid as a normal part of cacao fermentation. It is a characteristic item in the aroma of most raw cacaos. The amount retained by the bean in the case of the Criollo variety, where the fermentation is very short, is often negligible. In the case of the Forastero variety it varies. As previously noted, the acetic acid bacteria are more in evidence in cacao fermentations in the West Indies than on the Gold Coast and commercial cacao from Trinidad or Grenada usually contains more acetic acid than Accra cacao.

As the fresh pulp contains citric acid and, when fermented, acetic acid, the shell of both fermented and unfermented beans contains varying quantities of acid. The nib of unfermented beans, however, contains no free volatile acid. Fermented

beans always contain small quantities of acetic acid, the quantity depending on the period and kind of fermentation. The shell usually contains more than the interior. Harrison [42] found in the kernels of freshly fermented and dried Trinidad beans: Forastero, 0·6 per cent. and Calabacillo 0·9 per cent. acetic acid. The quantities found in the nib by the time the cacao arrives in Europe is appreciably less, thus Fincke [93] gives an average of 0·2 per cent. for Trinidad cacao nib, 0·3 for Bahia, and as much as 0·6 for San Thomé. Arriba, which receives little fermentation, has 0·1 and Gold Coast cacao 0·05 to 0·16 per cent. of acetic acid.

The acetic acid is firmly held by the cacao and only comes away very slowly on steam distillation. Its presence in the raw material for the manufacture of cocoa and chocolate has some disadvantages, e.g. the acetic acid will attack the whitewash on the walls of the cacao bean store and produce crystals of calcium acetate, and the acid vapours distilling from the roasting vessels corrode metal flues, but unless the amount present is higher than usual, it is accepted by the buyers without comment.

The question arises whether acetic acid production is an aid or otherwise to good fermentation. Schulte-im-Hofe [62] noted in the Cameroons (1899) that acetic fermentation was already evident on the second day, and considered that the presence of the acid helped to give a good product. And more recently (1929) Portères, in considering the kind of fermentation suitable for the different botanic varieties, suggested that acetic fermentation was good for the type of cacao grown in West Africa [85].

It has been suggested (e.g. by Briton-Jones) that acetic acid fermentation is essential because without it the necessary temperature to kill the bean is not obtained. Judging from the figures previously given by the author, the maximum temperatures due to yeast fermentation are above the lethal temperature of the bean, so that although acetic acid fermentation increases the temperature, it is not essential on this account.

In fermentation in boxes in the West Indies, temperatures over 50° C. are avoided because they usually indicate acetic acid development, but on the Gold Coast, with cacao in heaps, early high temperatures of 50° C. and over are not accompanied by excessive acetic acid development.

As mentioned when discussing the death of the seed, the author experimented [12] on the effect of 2 per cent. acetic acid on cacao beans both in the presence and absence of skin and pulp. After one day the appearance of the beans was similar to those fermented in the normal way for three days. In a control experiment using water in place of 2 per cent. acetic acid, the only change seen in the beans was the beginning of germination. It was evident that acetic acid rapidly penetrated the skin, helped to kill the bean and aided the distribution of the colour.

Hardy has made wider claims; he has contended that acid treatment not only simulates fermentation, but could actually replace it [55]. The author found that acetic acid treatment was not a satisfactory substitute for ordinary fermentation because the beans so treated, although possessing most of the properties of fermented cacao, did not develop on roasting the full aroma and flavour. Hardy's rejoinder was that *citric* acid might produce the aroma also, but the author, from certain experiments, is doubtful of this.

In the normal fermentation acetic acid exhibits the following properties which may be advantageous :—

(1) It rapidly penetrates the skin.
(2) It assists in killing the bean. Hardy's important contribution [54] on this point has already been discussed.
(3) It aids the distribution of the cacao-purple throughout the cotyledons.
(4) It aids hydrolysis, which may have some connection with flavour change. Whilst the caffeine catechin is decomposed by acid, R. V. Wadsworth and the author [76] have shown that the compound of theobromine probably with tannin present in the fresh bean is not decomposed by acid.
(5) It forms esters with the alcohols and some of these have a pleasant aroma.

It has the following disadvantages in relation to fermentation :—

(1) It retards the growth of the yeasts.
(2) It diminishes the oxidase reaction. As the reaction proceeds in the presence of 0·5 per cent. acetic acid and is not completely inhibited until 4 per cent. is

present, the retarding effect of acetic acid on the oxidation of the tannin in the cotyledons is generally small.

As simple treatment with acetic acid could not replace fermentation, the author determined to ferment some cacao in the normal way and start the internal changes earlier by its use. One pint of acetic acid in 43 pints of water was poured over 3,000 lb. of beans when they were put in the sweat box and the same amount added on the following morning [86]. This solution contained a higher percentage of acid than the pulp, but as it was poured over the pulp-covered beans the penetration was slow until the pulp had broken down and the acetic acid mixing with the pulp was diluted before it reached the skin. The normal changes occurred and were one day ahead of the control. It would appear that the acetic acid caused the death of the bean earlier, and thus allowed the ordinary colour changes to commence sooner.

On roasting the product, whilst no objection was made to its acidity, there was no evidence that the acetic acid had increased the production of the substances on which the characteristic aroma and taste depend. In these experiments the simple addition of acetic acid during fermentation was a slight advantage and its effect, if any, on the final product was unobjectionable. It would appear that small variations in the acetic acid content alone are not detrimental to the quality of the bean, but it may be in a fermentation, which is of such a type or such a length that an unusual amount of acetic acid is formed, that the associated bodies produced at the same time are objectionable.

In Germany the attention of scientists has been called to some very acid cacaos, notably those from the Cameroons. Whether the fault with these was due to acetic acid alone is doubtful—other more objectionable bodies were probably present. The relative humidity in the Cameroons is high and the rainfall very heavy. These conditions affect the fermentation and prevent sun-drying. Busse [46] in 1924 stated that whilst alcohol was beneficial, the production of acetic acid was harmful, and that the complete fermentation of the sugar of the pulp solely to alcohol was the ideal. In Germany and the Cameroons five years were devoted to a comprehensive research in an attempt to achieve this ideal.

Busse, Henneberg and Zeller [20] and others attacked the problem by making the following additions to the normal fermentation :—

(1) *Selected yeasts.*—Several attempts were made to find a yeast the use of which would result in a purely alcoholic fermentation with no acetic after-fermentation. All attempts failed, including the addition of pure cultures of selected yeasts. It was noted that the use of yeast from Venezuela resulted in a higher acidity than when yeast from Accra cacao was used, and that the yeast *S. anomalus* retarded the acetic bacteria by forming esters.

In Java in attempting to prolong alcoholic fermentation by adding yeast, de Haan [87] succeeded when he used Ragi (a mixture of mucors and yeasts), but could not prevent acetic acid formation.

(2) *Retarding bacteria.*—Bacteria were added with the object of diminishing the development of acetic bacteria. The use of *Bacillus Delbrucki* and lactic acid bacteria failed to achieve this in the Cameroons.

(3) *Retarding chemicals.*—Substances harmless to yeasts were added to check the growth of acetic acid bacteria. The substances included sulphurous acid, potassium meta-bisulphite, ammonium fluoride, lactic acid and tannin. Ammonium fluoride is obviously unsuitable on account of its poisonous nature, and in the author's opinion the presence of sulphurous acid in cacao would be more objectionable than acetic acid. The first three were tried in Germany and in the Cameroons, but failed in the latter to diminish the production of acetic acid.

Steinmann [24] by a similar experiment in Java obtained a more promising result. This was using Criollo cacao, which requires only a short period of fermentation. By adding sodium sulphite equivalent to 0·12 to 0·60 grams of sulphur dioxide per litre of beans he prolonged the alcoholic fermentation up to four days. He found that in order to prevent acetic acid development it was essential to stop at exactly the right point. The beans produced had a less astringent taste but their colour was too pale.

Steinmann, the author, and other investigators have

unsuccessfully attempted to diminish the production of acetic acid by other methods than those described above :—

(*a*) *By shutting out the vinegar fly.*—Steinmann showed that acetic acid was still produced in normal fermentation even though the vinegar fly (*Drosophila*) was kept out by netting. He found that the inoculation with acetic acid bacteria came from the air, the coverings and sides of the boxes, the hands of the workers, etc., and could not be prevented.

(*b*) *By shutting out the air.*—The author immersed a lidded box, 1 ft. cube, full of cacao in the midst of similar beans in a large sweat box. The temperature in the small box rose as rapidly as the temperature of the beans outside. The beans became slightly more acid than normal, possibly because they absorbed the sweatings which could not get away. After 6½ days fermentation they were externally much paler than usual, and internally they were a paler and brighter red.

Since the above experiment Eckmann [25] has shown that 11 out of the 20 varieties of cacao acetic bacteria he examined were capable of growth under anærobic conditions.

(*c*) *By the addition of foods for yeast.*—The author and others have considered that by the suitable addition of foods for the yeast, more alcohol and less acetic acid would be produced. The author by this method obtained more alcohol, but this resulted in the ultimate production of more acetic acid. As an example, the addition of invert sugar may be cited. About 10 cwts. of wet cacao were placed in a box and 3 gallons of water containing 3 lb. of invert sugar were poured over the cacao after it had fermented two days. A similar addition of invert sugar was made two days later. In two separate tests, the cacao produced was, contrary to expectation, slightly more acid in odour than the control. Analysis confirmed that there was more acid present.

Steinmann [24] tried the addition of Nicholls' glucose nutrient media without obtaining any obvious decrease in acetic acid production.

Ficker and Lilienfeld-Toal [32] by the addition of sugar and wine yeasts obtained much alcohol and by

the fourth day sufficient acetic acid to stop the internal changes in the bean.

The author concludes that the addition of sugars to fermentating cacao is only of value when there is an actual deficiency in the pulp.

The German investigators, Busse, Henneberg and Zeller, finding, as others have found, that it was impossible to prevent acetic fermentation, next turned their attention to removing the acid produced. The amount of acetic acid present rises during a long fermentation to a peak and then falls, owing to oxidation of the acetic acid by micro-organisms. As the acetic acid is reduced to zero, the objectionable butyric acid fermentation sets in. This gives a rancid odour and must therefore be avoided at all costs. The problem as these investigators saw it was to give a practical test which enabled the planter to stop at just the right point. Zeller proposed that 20 beans should be stirred with 100 cc. of water and 20 cc. titrated with N/10 alkali. The desirable volume to neutralise the acidity he gave as less than 1·5 cc., but not below 1·0 cc. The curves illustrate the kind of figures obtained (Fig. 1).

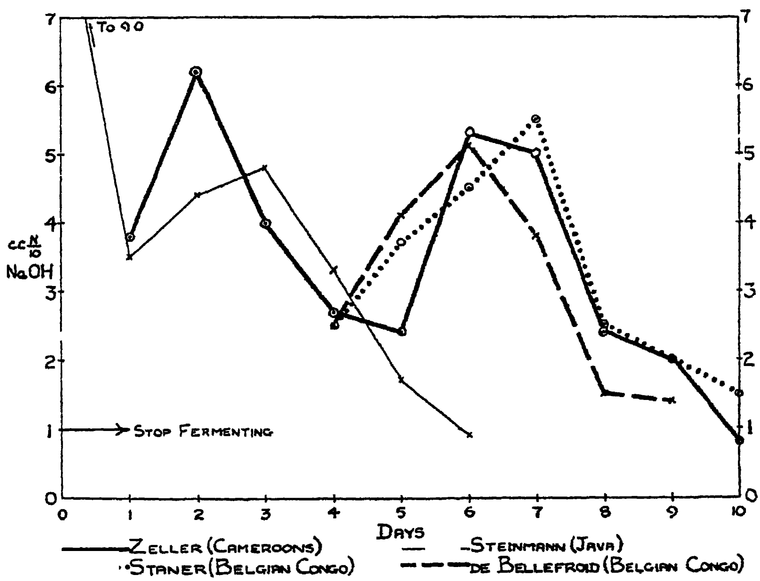


Fig 1—Acidity of Pulp—Zeller's Method

Showing changes as fermentation proceeds Steinmann's results are on beans from selected pods after 6 minutes mixing with water The plotted figures for de Bellefroid are the mean of 4 tests

Beirnaert's figures for acidity on the Congo [89] are not included; they are lower throughout and the rapid decline occurs on the fifth day. It is interesting to note that the rise to the peak and the fall below 1·5 cc. in the wet season in the Cameroons may take as long as 14 days.

Whilst Zeller is to be congratulated on having made a brave attempt to supply a scientific test for planters for determining the correct duration of fermentation, the test itself is open to criticism. Steinmann [88] has shown the wide variation (represented by 2·9 to 9·0 cc.) in the amount of acid obtained from beans from individual pods. He has also shown that the acidity of the water extract is much affected in the test by the period of soaking and also by the size of the beans. If the experienced chemist cannot obtain concordant results the test can hardly be a safe guide in the inexperienced hands of the planter.

The figures given by Zeller himself show such irregular variation from day to day as to illustrate what is already known, that the acidity is developed irregularly in the mass of the beans.

As the value of cacao is judged by various properties of the cotyledons and is little influenced by the acidity of the pulp, it will be obvious that it will be necessary to determine for each cacao and each market the desirable figure at which to stop the fermentation. From Staner's figures previously quoted when discussing the total acidity of the pulp [49], and from de Bellefroid's [90], the rise and fall of acidity appears to be related to time in a similar manner in the Belgian Congo and the Cameroons. On the other hand, Steinmann in Java found that if he allowed the period necessary to reach the stated acidity—that is five or six days—the broker said of the product that "every charm belonging to Java cacao has disappeared."

To allow fermentation to proceed for ten or more days is not, for most kinds of cacao, a sound procedure. The author would describe such cacao as over-fermented. It has a frail shell and on arrival in Europe has a high percentage of broken shells and fragments of beans. This is a more serious fault than a faint acidity.

In the ordinary case one can only advise the planters to prevent the production of excessive amounts of acetic acid by avoiding too much aeration at the later stages. In those

rare cases where excessive acidity is produced in spite of precautions, it might be an advantage to wash out the sweat boxes with a dilute solution of sodium sulphite.

In his patent [91] Zeller has attacked the problem of preventing high acidity in another way, that is by the application of heat. He ferments the beans in a drum and " when the alcoholic fermentation has ceased, the raised temperature is applied to the drum before acetic fermentation starts." Strictly, this is impossible, as the two fermentations overlap considerably. When the alcoholic fermentation has ceased he heats the beans in damp air at 55-65° C. for 24 to 30 hours, and this destroys bacteria, yeasts and moulds. He washes off the mucous covering and first heats and then dries at the same temperature (55-65° C.) for two or three days. The author has not seen cacao produced by this process.

Another patent is that of Bruno Müller [92]. He describes long narrow fermenting boxes, in which he claims that a purely alcoholic fermentation is obtained by avoiding loss of juice and preventing overheating by ventilating amply through pipes. The author is not clear how this would prevent acetic fermentation.

The present position may be summed up as follows: In the normal fermentation the production of acetic acid is unavoidable. Its presence during the early stages of the fermentation of Forastero cacao has some advantage in producing the initial changes earlier. In the later stages, if unusually high in amount, it will retard oxidation of the tannins. In the final product its presence is without advantage and in some respects undesirable.

Manufacturers have become accustomed to Forastero cacao containing about 0·1 to 0·3 per cent. of acetic acid. They have worked out their processes using such beans and during these processes the acetic acid is slowly driven off. If a sample of cacao, for example, from Trinidad, were offered for sale which had no acetic acid present it would be regarded as unusual. Whether such cacao would at first obtain a higher price is doubtful, but if cacao of a recognised mark were consistently produced without the faintest vinegary tang and all its other properties were as good as usual, its value, in the author's opinion, would gradually rise.

Complete freedom from acetic acid can be obtained by

alternatives to fermentation to be described later, but so far these alternatives have produced beans deficient in certain valuable properties.

The Effect of Ripeness

In Nigeria and the Gold Coast about 23 weeks elapse between the opening of the flower and the production of the pod ready for picking. The pods become mature, that is full grown and with the seeds able to germinate, in about four months after setting. The mature pods take about one month to ripen. As the cacao pods are seldom collected more often than once a month and frequently at wider intervals, it is obvious that, however carefully picked, they cannot all be of the same degree of ripeness.

As the pod becomes mature, the mucilage inside the bean decreases. When the mature pod ripens, the more notable changes take place in the pulp on the bean rather than in the interior. One change has been noted in the interior by Fincke [75], who found that ripening increased the percentage of theobromine present. In Accra nib he found: unfermented, unripe 1·53, ripe 1·76 per cent.; fermented, unripe 1·18, and ripe 1·37 per cent.

The Gold Coast pod is silvery green[1] when unripe, the beans being embedded in a firm, and often faintly greenish, pulp. The author has noted in unripe Gold Coast cacao that the pulp next the skin of the bean is particularly opaque and hard and gives the impression of a felted testa several times the thickness of the skin. The planter will naturally do his best to avoid picking immature or absolutely unripe pods—if only for the reason that the beans are difficult to remove and separate. The colour indications of ripeness vary with the different varieties. On the Gold Coast ripe pods are yellow and no pod should be gathered unless more than half of it is yellow.

The author has fermented unripe cacao (*a*) in bulk and (*b*) in small quantities in muslin bags in the midst of ripe cacao. In an early experiment in Trinidad [86] sufficient wholly unripe pods were picked to give 600 lb. of wet cacao. Apparently there was insufficient sugar properly to maintain the fermentation longer than 24 hours and the temperatures reached were much below the normal (Fig. 2). The product

[1] On Ridgway's colour standard it is 37'c, that is between Deep Lichen Green and Rejane Green.

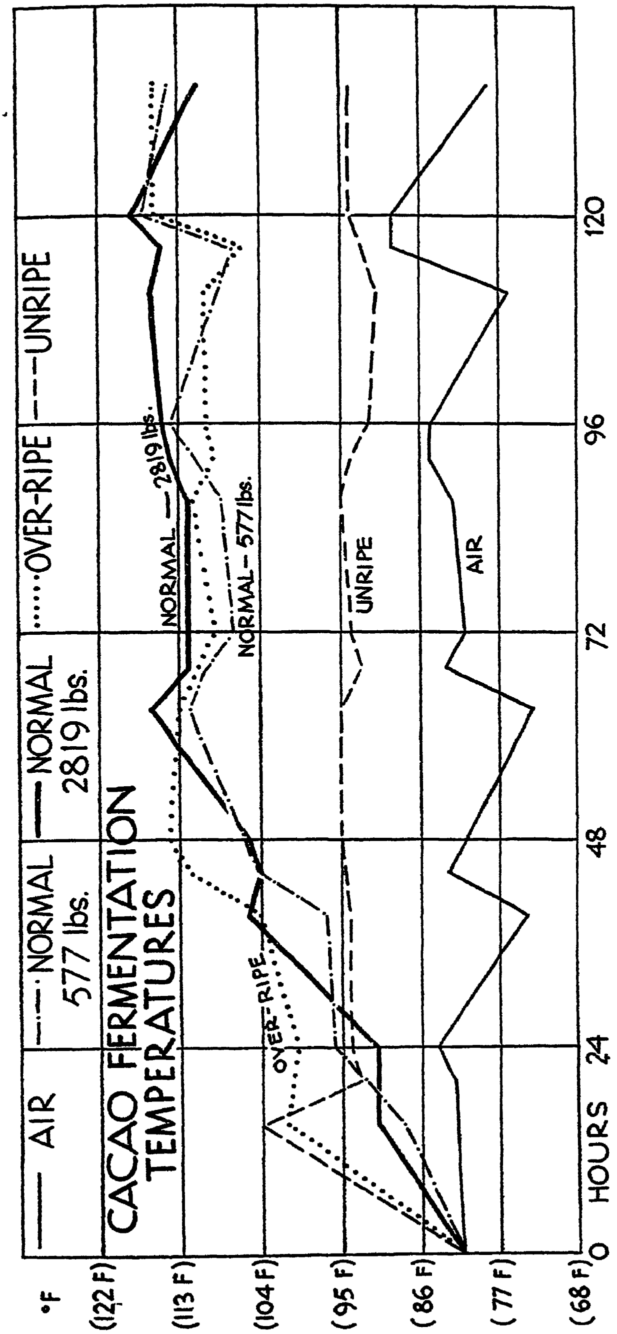


FIG. 2.—CACAO FERMENTATION TEMPERATURES (TRINIDAD)

Temperatures obtained from 600 lb. lots of unripe and over-ripe cacao compared with 600 lb. and 2,800 lb. of cacao as generally picked

was thus insufficiently fermented. Further, the beans became gummy and slimy. The yield was low and the quality inferior, the dried beans being flat and woody. The conditions in this experiment were abnormal, for in a normal fermentation any unripe cacao is surrounded by ripe cacao and hence subject to similar conditions of temperature, etc. Unripe cacao does not, however, undergo the normal changes when enclosed in a muslin bag and placed in the midst of ripe cacao. In experiments in Trinidad and later at Kumasi [6], the author found that if the beans were immature or absolutely unripe the product was abnormal. The pulp became gummy or ropy and the oxidation of the cacao-purple proceeded more slowly. Some unripe beans, presumably deficient in cacao-purple, become a pale brown. Many of the dried beans were small or shrivelled and internally 50 per cent. showed a definitely close texture, as against 20 per cent. in the normal product. On roasting, those beans which were shrivelled had a sour odour.

H. A. Dade has sent the author unripe cacao fermented by him at Aburi in a similar manner to the above. He obtained similar results. He called attention to some 59 per cent. of beans which had a " very close texture, cheesy consistency and light milk chocolate colour."

In these experiments on unripe cacao a fair proportion of the beans always appear normal, which suggests that in the same pod the degree of ripeness may vary.

The author has concluded from these various experiments that any unripe cacao—the degree of unripeness was not specified—produced of necessity an inferior product. This opinion requires some modification since the author has seen a sample of Nigerian cacao sent to him by Laycock from Nigeria, in the preparation of which he used beans from green pods gathered rather more than four months from the flower. The product was as good as average Nigerian cacao. This experiment has been repeated by O. J. Voelcker [94], who used pods definitely green and gathered probably three to five weeks before maturity. He obtained greater loss than usual on drying, but the cacao was normal and contained no more purple beans than are found in ordinary Nigerian cacao. Laycock has, however, proved in his published experiments [28] that cacao a little over-ripe

gives the least percentage of purple beans in the fermented product.

The author has fermented definitely over-ripe cacao in Trinidad [86] and on the Gold Coast [6]. He noted that provided there is sufficient pulp a brisk fermentation commences earlier than usual, but the final product is normal. If the pods are considerably over-ripe, for example, if they have been left on the trees four to six weeks after acquiring the colours which indicate ripeness, the shell of the dried beans is fragile. This is a serious commercial disadvantage.

After considering these various experiments the author remains of the opinion that the best product is obtained when either pods just ripe are gathered or those which have been ripe for one or two weeks. By doing this one avoids producing beans which are characterised as unripe, that is which are small in size and lacking in plumpness and have a woody hardness and a shrivelled yet tightly fitting skin.

With regard to hard beans and shrivelled beans, it should be mentioned that ripe Forastero beans which have been only fermented three days are, when dry, purple and *very hard*, and that the use of only ripe pods will not prevent one or two of the beans in every hundred being flat and *shrivelled*. In more than half the pods gathered will be found one immature bean in which the cotyledons are undeveloped and the shell filled out with mucilage. These, on fermenting and drying, become flat and shrivelled.

IMPROVED METHODS

(*a*) *Layering before Boxing*

Two modifications founded on scientific principles have recently been put forward from Trinidad. The first is advocated by Briton-Jones [22] as giving increased speed of operation and greater uniformity of product. The modification consists in making the beans, freshly taken from the pod, into a layer 9 in. deep, preferably resting on a wooden floor. The beans are left freely exposed to the air but protected from the rain. The aim is to provide aerobic conditions for the yeasts. The procedure is varied slightly according to the weather :—

In ordinary weather.	In very wet weather.	In dry weather.
1. Leave layer for 12 hours	For 24 hours.	As in ordinary, but first sprinkle with dilute molasses.
2. Turn right over.	Turn.	
3. Leave layer for 12 hours.	For 24 hours.	
4. Transfer to Box No. 1 for 24 hours.	As in ordinary.	
5. Transfer to Box No. 2 for 48 hours.	As in ordinary.	
6. Transfer to Box No. 3 for 48 hours.	As in ordinary.	

The free exposure of a thin layer to the air for 24 hours results in a strong growth of yeast throughout the mass, whereas during the first 24 hours in the ordinary box fermentation this only occurs in the surface layer. On putting into Box No. 1 the temperature rises rapidly. This flying start enables the planter, if he wishes, to restrict the amount of air exposure in the later stages and thus reduce acetic acid development.

(*b*) *Fermenting small Quantities*

The chief causes of the lower quality and hence lower price of the cacao from peasant proprietors as compared with estate or plantation cacao are (1) less frequent picking and less care in fermenting and (2) the difficulty of fermenting small quantities. It requires great skill to obtain 100 per cent. perfectly fermented beans from 100 lb. of wet cacao, because the area exposed is, relative to the quantity, very large and this results in excessive loss of heat and loss of moisture. As the author has shown [6], if the mass is left undisturbed the beans at the bottom and sides may not be raised above their lethal temperature and in some cases may germinate.

As over 60 per cent. of the world's cacao is produced by farmers with small holdings, the problem of obtaining a good product from small pickings is an important one. There are in general two methods of approach—the one is by improved methods for small quantities and the other is by co-operative fermentaries.

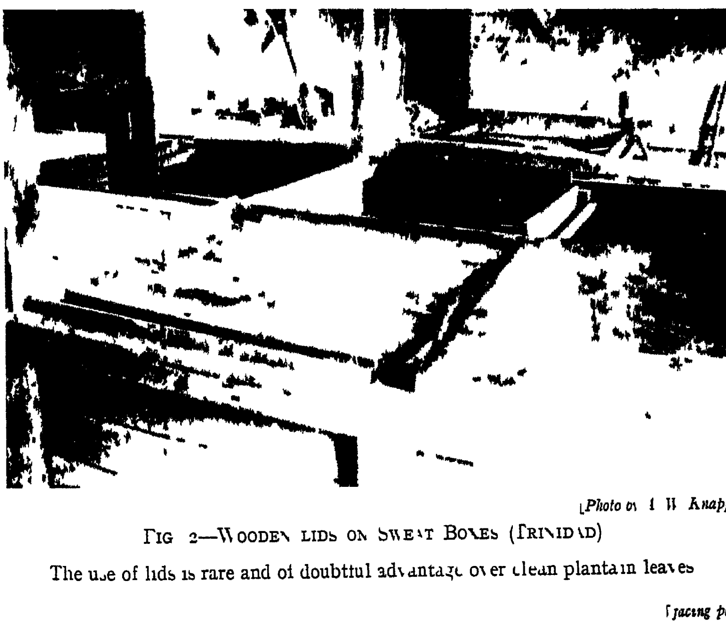
For the improved fermentation of small quantities McDonald has suggested the use of his solar frame method [95] which was specially designed for this purpose. The author proposed in 1913 the use of a box within a box [14]. McDonald has greatly improved on this. His solar frame consists of a box within a box, painted black and having a glass lid. In this arrangement the sun's heat is trapped and

PLATE III

Photo by A W Knapp

FIG 1—SMALL BOXES USED FOR FERMENTING CACAO

Gin boxes etc at Mpatasie (Kumasi) Thickly covered with plantain leaves and put in the sun by wall of native house Raised off ground to keep out white ants

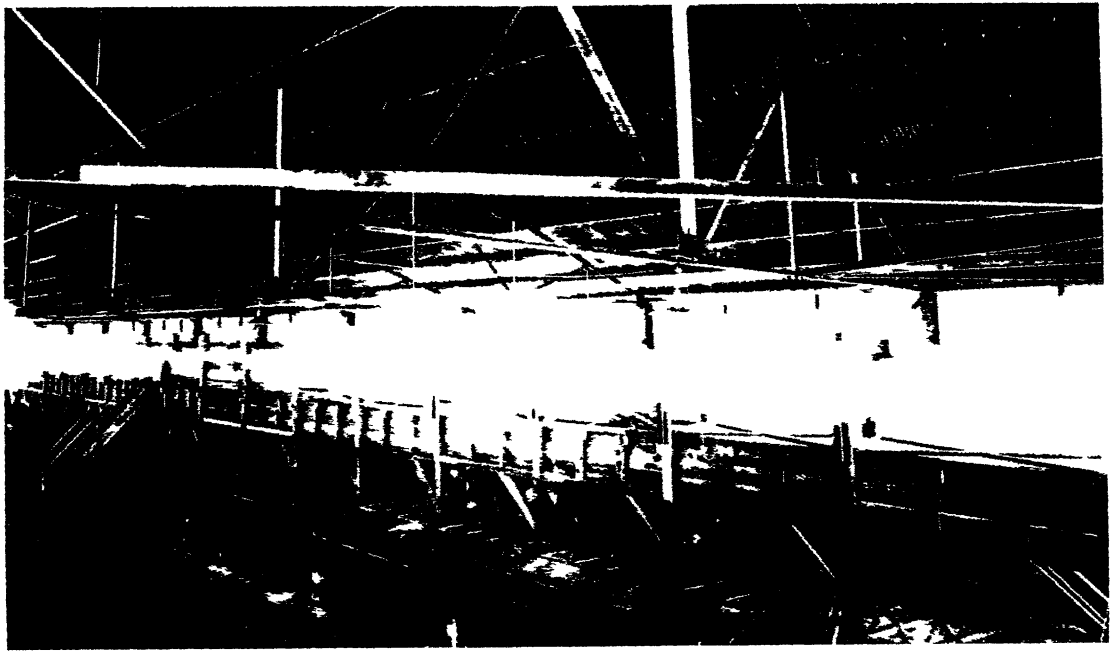


[*Photo by A W Knapp*

FIG 2—WOODEN LIDS ON SWEAT BOXES (TRINIDAD)

The use of lids is rare and of doubtful advantage over clean plantain leaves

PLATE IV



Cacao Fermenting Vats in Costa Rica
(United Fruit Company)

[fu ng t1g. 3.1]

utilised to raise and maintain the temperature of the envelope of air which surrounds the sweat box proper. To remove the risk of the drying out he maintains the humidity of the air envelope by having on the floor of the frame some wet sacking which dips into a tin full of water. Further details are required showing how the sweatings drain away without saturating the box with the decomposing liquid.

The author has examined a number of fermentations on the Gold Coast in which small quantities were used—thus, in a heap, 2 ft. diameter; a shallow basket, 1 ft. 9 in. diameter; or a box, 2 ft. by 1 ft. 3 in. by 1 ft. (Plate III, Fig 1). The temperatures generally run higher than in Trinidad despite the small quantity. The temperature of the centre by the second day was often 41° C. (106° F.), but the sides and bottoms were cold and the final product contained some unfermented and germinated beans.

McDonald claims that the use of his frame gives *an even fermentation without turning.* The author has examined a sample from 60 lb. of wet cacao fermented in this device and can say that it was uniform and at least as good as the product of the ordinary box fermentation where 4,000 lb. wet cacao was used. It was not quite so strong as normal Trinidad cacao, being a little blander and less acid. Further, unlike the product of some other methods, it had the normal full chocolate aroma on roasting.

The advantages of a wide use of the solar frame fermentary, as against the unturned heap, is obvious. Comparatively simple as it is, the author fears it may be too elaborate for the Gold Coast farmer. The adoption of the simplest box has not found general favour there and even so essential a thing as the simple turning of the heap is often left undone.

The author agrees with C. Y. Shephard, the economist, who regards co-operative fermentaries as the most promising method of improving the cacao of the peasant proprietor and making it similar to plantation cacao. This has already been accomplished in Trinidad and Tobago and Shephard has shown in detail how it could be done on the Gold Coast [96].

In a few places (e.g. San Thomé) on large plantations mechanical aids have been used for a considerable time for transporting the cacao at various stages. An example of a good layout from this standpoint is that of the United Fruit Company in Costa Rica.

Alternative Methods to Fermentation

Perrot [97], in 1913, proposed that, instead of fermentation, the pulp should be removed by treatment with dilute carbonate of potash and the bean sterilised by steam. The author found [98] on testing out this method that the cacao produced had the properties of either unfermented or under-fermented cacao. When the exposure to steam was insufficient to kill the bean it appeared unfermented; when the exposure was ample to kill the bean the enzymes were liable to be destroyed and hence no browning occurred and the bean appeared insufficiently fermented.

Fickendey [40] was the first to demonstrate that most of the changes observed in cacao during fermentation would occur if the beans were simply killed under any conditions, whether mechanical, physical, or chemical, which left the enzymes unimpaired. Below are set out some of the conditions which kill the bean but do not destroy the oxidase :—

Process.	Effect on Bean.	Effect on Oxidase.
1. Freeze (0° C.).	Dies in 3 hours.	Not destroyed.
2. Warm to 45° C.	Dies in 2 hours.	Active.
Warm to 60° C.	Dies in ½ hour.	Active.
3. Soak in dilute acetic acid (from 0·005 to 2·0 per cent.)	Dies.	Slightly retarded.

The use of acetic acid as an alternative to fermentation has already been discussed. Fickendey proposed as early as 1912 that after the removal of the pulp the beans should either be (1) kept at 0° C. for 3 hours, or (2) heated to 50 to 60° C. for 24 hours and then in both cases dried. The author had both these processes tried out in Trinidad and was disappointed to find that whilst the beans produced were much better than unfermented beans and showed to a considerable extent the colour changes associated with fermentation, when they were roasted the characteristic aroma and flavour of chocolate were lacking.

Proposed Heat Treatments

Author.	Date.	Temperature.	Period.
Fickendey .	1912	50-60° C.	24 hours
McLaughlin .	1923	49-54° C.	5-7 days
Stevens . .	1924	40-60° C.	Several days

More recently (1924) F. L. Stevens has approached the problem of cacao curing in a very similar manner to Fickendey and propounded a similar theory, namely, that " the essential process is not a fermentation at all." In his experiments the beans, in air or covered with water, were maintained at 40 to 60° C. (104 to 140° F.) for several days. This gave the desired internal colour changes without any development of acetic acid. Stevens avoided giving specific and detailed directions for working in the tropics, but his claims that the method would take less time than the fermentation process and that the product would be superior revived the interest in alternatives to fermentation [51].

While on the Gold Coast the author, sometimes in collaboration with H. A. Dade, carried out a few trials of the Stevens process. The first point that became evident was that if the acid juice could not drain away the beans below the surface of the juice showed no browning, although the oxidase was not destroyed. This is of interest in relation to the McLaughlin patent method of curing cacao [99], in which the beans are heated without access of oxygen to 49°-54° C. for five to seven days, which causes the " autogenous hydrolysis of the astringent matters " without loss of bean substance. The colour change is described as purplish-red to reddish-brown. Any browning in the absence of air is surprising, and presumably the colour of the final product, cinnamon brown, is produced by air drying.

The second point was that maintaining the beans at 50° C. did not prevent the growth of moulds. These appeared in three as against five days in a normal undisturbed fermentation, and were recognised by Dade as *Aspergillus fumigatus* and *Mucor Buntingii*.

The third point was that Stevens had given no information on the destruction and separation of the pulp. The fourth and most important was that the beans were browner internally than after the same period of ordinary fermentation—the browning showed in 24 hours mainly in the centre of the bean along the joining faces of the cotyledons, and in five days showed a fine and uniform brown—and when they were roasted their flavour and fragrance was feeble and inferior to the ordinary product. Otherwise they resembled well-fermented beans.

The author endeavoured to devise a modification suitable for the African farmer. It was essential that the process should be very simple, that the pulp should be sterilised and its removal rendered easy and that a suitable temperature should be obtained for a short period. Stevens stated that the oxidation proceeded whether the beans were in air or under water, but both Lilienfeld-Toal and the author found that water retarded the enzyme action. Water was used solely because of its convenience and the drying period relied upon for the oxidation. The following directions were given:—

> Half fill a vessel with cacao beans straight from the pod. Add an equal volume of boiling water so as to fill the vessel completely, and mix vigorously for a few minutes. Allow to stand for 24 hours. Run off the water as far as possible and dry the beans in the sun in the usual way.

The author is indebted to H. A. Dade and H. Nicholas for trying this out on a large scale, one at Aburi and the other at Kumasi. In one experiment Nicholas used sufficient Amelonado cacao to produce 600 lb. dry weight. Fifty-nine new petrol tins were used for the steeping process and an old barrel for preparing the boiling water. Twelve fires were necessary and the scene looked like a setting for a Hollywood Gehenna. It was found that the temperatures after three minutes stirring were: mean 59° C., minimum 55° C. and maximum 71° C. Examination later showed that, judging from the absence of colour distribution, 2 per cent. of the beans were not killed. On draining off the water most of the pulp came away and as a result the beans dried readily. When dry the beans were clean externally and the usual mixture of purples and browns internally. The shell had the defect of being more brittle than usual. The roasted beans had the flavour and odour of chocolate, but not so well developed as in ordinary fermented cacao. Better results would probably have been obtained if the beans had only been steeped for one hour instead of 24, and special care had been taken to dry them slowly in a thick layer. As the process was much more trouble than fermentation as practised on the Gold Coast and did not produce so good a product it cannot be recommended.

The most important test of the process was made in Costa Rica. The Manager of the Costa Rican division of the United

Fruit Company was delighted with the original samples prepared by Stevens and Stevens' methods were applied on the plantations, but the cacao produced "had no character in the way of aroma and flavour" [100]. Zeller appears to have had some success with it in the Cameroons in that he was able to produce a marketable product from beans in which the pulp had deteriorated (e.g. those attacked by *Phytophthora*).

The Stevens' alternative to fermentation has not become a commercial process, but it remains of great interest on account of its relation to the theory of cacao fermentation. Whilst it has not proved a satisfactory substitute, the knowledge of how certain results can be obtained may prove of value if properly applied to modify the established processes.

Combined Fermentation and Heat Treatment

Preuss reviewed Stevens' work [101] and considered how the basic facts concerning the death of the seed and the action of the oxidase might be applied to improve the ordinary fermentation and drying. He pointed out that Stevens had given no information on the time required for the enzyme to act or on the percentage of moisture in the bean at which the activity of the enzyme can best be used. He considered these and recommended the following procedure:—

(1) *Removing the Pulp.*—Raise the fresh cacao to 45° C. and ferment for 24 hours, or the shortest period which will loosen the pulp so that it can be washed away.

(2) Remove the pulp with warm water (45° to 50° C.) and thus avoid further fermentation.

(3) *Plumping.*—Heat the cacao in stagnant air at 45° or 60° C. to make it plump.

(4) *Drying.*—Place the beans in a drying atmosphere at 45° to 60° C. until they contain 15 per cent. of water. Now remove them to the oxidising room. Operations 2, 3 and 4 take about 24 hours.

(5) *Oxidising.*—Allow oxidation by keeping in more or less stagnant air at 45° to 60° C. for two or three days.

(6) *Complete the Drying.*—This may take 12 hours.

Cacao was cured according to Preuss' recommendations for applying Stevens' method, by de Haan in Java [102], the final drying being in the sun. Presumably the cacao was of

the Criollo variety. The opinion of experts was that the product had an unsatisfactory flavour and taste.

Two patents appeared in 1928 for machines for processes resembling the above. One is Zeller's patent [91] described at the end of the section on the production of acetic acid and the other is Bruno Müller's [103]. Both allow alcoholic fermentation followed by a period of heating in damp air prior to drying. They aim at carrying out the oxidation of the tannins in a scientific manner. Preuss mentions the "Brumutro" drying house as one in which conditions can be well controlled. Even in those areas where large plantations are common the difficulties with power, repairs and technical oversight will prevent the general adoption of machines requiring skilled attention unless it can be proved that the product will obtain a considerably enhanced price. Crude as the conduct of the ordinary fermentation of cacao appears, the scientist who sets out to devise a more efficient process at no greater cost has a difficult task. The pulp must be got rid of, the shell hardened (not made weak by washing), the bean must be killed, the correct changes in the colour and flavour occur (in the author's opinion oxidation can easily be carried too far) and the product have the ability to develop the chocolate aroma on roasting. With no labour save that of putting in a box and turning once every one or two days, the ordinary fermentation provides the necessary temperature, moisture and other conditions. On a large scale, with the co-operative fermentaries, one can conceive of detailed control at a reasonable cost, but for every planter to set up such an apparatus would certainly prove more costly than the present methods.

In most of the published experiments on fermentation, when there is any mention of aroma and flavour it refers to the raw cacao. This is of value in judging cacao and the mixed odour of acetic acid and esters is a useful guide to the buyers who know exactly what to expect with different kinds of cacao. In experimental samples it may be misleading and the crucial test is the aroma and flavour on roasting.

A number of changes have been noted during fermentation which would affect the flavour of the raw bean: the complete destruction of the sweetish catechin by oxidation to a probably flavourless body; the complete destruction of the catechin

caffeine, the bitter caffeine being liberated and the catechin oxidised; the probable splitting off of the lightly held theobromine with its marked bitter taste and its decrease owing to diffusion into the shell; the partial oxidation of the astringent catechu tannin and of the cacao-purple. All these changes might be expected to be produced by heat treatment equally with fermentation. Is the flavour of the heat-treated cacao milder because oxidation has been carried too far, or is the lack of chocolate flavour due to other causes? In fermentation we have also the absorbtion of certain substances from the pulp, the most obvious being alcohol and acetic acid.

The Aroma of Cacao

It is advisable to draw a sharp distinction between the aroma of raw and roasted cacao, although the two may be connected. The planter and broker refer to the aroma of the raw cacao, but to the manufacturer the aroma and flavour which will develop on roasting, or other heat treatment, is more important.

(*a*) *The Raw Bean.*—The dry raw unfermented bean has little odour. It resembles that of the fermented bean but is flatter and faintly earthy. The fermented bean has a vinegary odour, faint but sharp, together with a feeble sweet fragrance, either wine-like or else resembling geranium. Whilst every kind of cacao shows differences to the sensitive nose, Criollo and Forastero do not differ essentially. Washed cocoas have the feeblest odour. Arriba cacao is peculiar (see below).

(*b*) *The Roasted Bean.*—On roasting and to a less extent on boiling, the unfermented bean develops a strong vegetable odour, totally different from the chocolate odour of heated fermented beans and reminiscent of broad beans.

The author concludes that there is present in unfermented beans a substance or substances (A) with little odour which on heating to 100° to 130° C. produce a volatile substance with a strong odour unlike chocolate. This substance (A) is destroyed during fermentation and drying and there is formed another substance (B). This has little odour, but on heating to 100° to 130° C. is changed into a volatile substance with the heavy sweet odour of chocolate.

The undesirable substance (A) is not destroyed by simply killing the bean (whether by heat or fermentation), but disappears by some action—probably oxidation—when the bean is left in a moist condition. The desirable substance (B) is formed when the bean is killed by heat or fermentation and subjected to heat in a moist condition. This action, presumably oxidation, is essential, but the amount produced is much greater following fermentation than after simple application of heat, freezing, or treatment with acetic acid.

The author tested the stability to light and air of the substances giving these odours by keeping the beans in bottles under similar conditions for 15 years. The odour (and odour-producing constituents) of the raw beans, both fermented and unfermented, appeared unchanged; that of the unfermented roasted bean was little changed, but the odour of the fermented roasted beans was completely changed, only empyreumatic odours remaining.

The original substances (A) and (B) are very stable, as is the substance produced by heating (A), but the chocolate aroma is only moderately stable.

The only information we have as to the composition of the essential oil of cacao is supplied by Bainbridge and Davies [17]. By steam distillation of *roasted* Arriba cacao they obtained 0·001 per cent. of an oil with a very powerful aroma of cocoa. It contained about 50 per cent. of d-linalool, over 5 per cent. of hexyl (?) butyrate, and smaller percentages of amyl propionate, linalool acetate, amyl acetate, hexyl (?) propionate and amyl butyrate.

Unfortunately, raw Arriba cacao, as indicated above, is different from all other cacaos; it develops, though unfermented, an aromatic and spicy odour reminiscent of oil of coriander, which suggests the presence of d-linalool. And further it cannot help us greatly in any theory of the aroma development due to fermentation because Arriba cacao is always a mixture of fermented and under-fermented or unfermented cacao, usually containing 30-40 per cent. of the latter. It is probably incorrect to assume that the essential oil which Bainbridge and Davies obtained from Arriba cacao gives to all roasted cacaos their characteristic odour. If, however, this is assumed, one can possibly account for the esters by reactions in the pulp, but so far no one has suggested the nature of the substance

in the bean which is produced during fermentation and which on heating to 100° to 130° C. gives d-linalool.

There is insufficient knowledge on which to formulate a theory, but the author's observations on fermentation and heat treatment indicate that the essential substances are produced preferably by fermentation (and to a less extent by heat) plus prolonged oxidation by the oxidase. As we have noted (p. (309), Hardy has suggested that the citric acid in cacao sweatings may play a specific part in the development of the aroma. Certain isolated facts should also be mentioned. Fincke states that the aqueous solution of the tannins possesses a smell [93]. Fresh cacao beans have been shown to contain acetic aldehyde [104] and possibly other aldehydes are formed. Schmalfuss and Barthmeyer [105] found 0·00012 per cent. of diacetyl in cocoa powder. The odour suggests that the raw bean contains geraniol, from which part of the linalool may possibly be derived.

We have seen that scientists have made valuable contributions to our knowledge of fermentation, but that no theory of the production of the desirable bean is sufficiently complete to enable us to state an alternative to, or improvement on, the traditional methods. In tracing out how the natural processes give us the desirable qualities, many things have been made clear, but the production of the substances which on roasting give the characteristic odour and flavour remains obscure.

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GOLD COAST BAUXITE

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The Gold Coast contains two large groups of bauxite deposits as well as some smaller deposits, of which two are important.

All the bauxite is laterite[1] which has been locally enriched in alumina. It occurs in wide horizontal sheets from 20 ft. to 60 ft. in thickness, the bauxite segregations being remnants of extensive laterite cappings to old peneplaned surfaces. These now form plateau residuals at altitudes of 1,600 to 2,600 ft.

The Gold Coast bauxites are mainly gibbsitic and so have a high water content. Some areas are rather ferruginous and fairly high in titanium dioxide but make up for this by their low silica content. Locally, however, white or cream bauxite, with very low iron content, occurs. Most of the bauxite is derived from steeply-dipping and sharply-folded phyllites, lavas, ashes and tuffs of the Birrimian system (pre-Cambrian), but that at Ejuanema is derived from nearly flat-bedded clay-shales belonging to the Voltaian, a system of shales and sandstones, etc., which rests unconformably on the older metamorphosed and igneous rocks and covers a large part of the Northern Territories.

The lateritised peneplane on which the bauxite deposits occur, is probably of Tertiary age, its dissection, by means

[1] Fermor's definition of a "true laterite" is adopted.

of which refinement was brought about, being controlled by the widespread gentle flexures and jointing found in the younger rocks and believed by the writer to be associated with the Alpine movement. If this is the case, the age of the Gold Coast bauxite deposits is probably much the same as that of the chief deposits of the world, namely those along the Mediterranean, in India, the Guianas, and the United States of America, all of which deposits were formed on land surfaces of post-Cretaceous age.

Preservation of the deposits is due to the great resistance of laterite to weathering and the flat surfaces which reduce mechanical erosion to a minimum. Erosion is, however, proceeding laterally by undercutting the edges of the plateaux and causing large blocks to tumble down the steep hill slopes.

For a more detailed description of the Gold Coast bauxite deposits, the reader is referred to *Bulletin No. 7 of the Gold Coast Geological Survey*, obtainable from the Gold Coast Government or the Crown Agents for the Colonies.

Mode of Formation

The writer inclines strongly to the view of the late Professor Harrison "that the action of primary lateritisation is due to the action of carbonated ground waters." He believes that rain water, carbon dioxide and humic acid are the main reagents involved. These break up the silicates, lime and magnesia being taken into solution mainly as bicarbonates, whilst the alkali carbonates probably assist in the removal of silica. In certain areas sulphates are formed by the action of sulphuric acid derived from the oxidation of pyrites and other sulphides commonly found in the Birrimian rocks.

A sample of water from a pit sunk in bauxite, analysed at the Imperial Institute by W. H. Bennett, gave the following results :—

Dissolved gases in parts per million by volume

CO_2 . .	18,200
O_2 . .	3,500
N_2 etc. .	8,800

The suspended matter amounted to 11 parts per million by weight, whilst the total soluble salts, in parts per million by weight, was 62, of which one-half consisted of bicarbonates of lime and magnesia.

Carbon dioxide and methane have frequently been noted in shafts in bauxite and when sinking it is necessary to take precautions to safeguard workers. A sample of gas from the bottom of a shaft on Mt. Supirri gave the following result on analysis: nitrogen, helium and argon, 12·5 per cent.; hydrocarbons, 1·0 per cent.; carbon dioxide, 10·2 per cent.; methane, 76·1 per cent.; and oxygen, 0·2 per cent.

There is clear evidence in the field that where gentle hollows exist in the surface of the bauxite—usually in the centre of hills—the reducing conditions brought about by swamp vegetation result in refinement of the bauxite. Iron is leached from the bauxite, oxidised and redeposited at the margins of the basins where it is thus brought into the zone of lateral erosion. Thus, the refinement or enrichment of normal laterite to bauxite is bound up with the dissection of the original peneplane surface, though the formation of the primary laterite capping required a prolonged period of quiet chemical weathering free from mechanical erosion. This distinction of the two processes involved is most important and a clear appreciation of its significance is of great assistance both scientifically and commercially.

It is true that basic rocks are more easily lateritised than acidic ones, but it should be remembered that a laterite too rich in iron will not be subsequently refined to good bauxite, so that, in general, igneous rocks of intermediate composition and rich in alumina are more favourable than basic rocks. Lavas are generally more easily broken down than coarse-grained deeper-seated rocks. Phyllites and shales show some increased concentration of alumina over the igneous rocks from which they were derived, and are eminently suitable for the formation of bauxite deposits.

It has already been stated that the Gold Coast bauxite occurs mainly at altitudes of from 1,600 to 2,600 ft. On benches and terraces at lower elevations the thickness diminishes until at 1,000 ft. no deposits of bauxite of commercial importance have been found. Thus it appears that bauxitisation may be regarded, for practical purposes, as having ceased.

Between the base of the bauxite and the underlying rocks is some 2 ft. of cream clay-like material, usually known as lithomarge, in most places slightly coloured by iron staining. From its stratigraphical position it appears to be a stage in

the breakdown of the rocks, and analyses show it to be intermediate in composition as well as in position. If, however, aluminous lateritisation is now dormant it is possible that originally colloidal lithomarge may in time alter to the crystalline hydrous aluminium silicate, kaolin, and form an end-product which cannot subsequently be lateritised.

The two following tables give analyses of typical rocks from which the bauxite is derived, and of specimens showing the change in composition that has taken place :—

Analyses of Typical Rocks from which the Bauxite is Derived

Ref. No.	18787	8137*	7555*	2047	6365	19051	A
Al_2O_3	20·62	14·71	14·02	18·20	15·73	28·38	18·0
Fe_2O_3	1·77	1·24	1·48	4·69 (Fe₂O₃ + FeO)	6·59 (Fe₂O₃ + FeO)	18·15 (Fe₂O₃ + FeO)	1·6
FeO	4·65	3·51	10·87				5·0
TiO_2	0·84	0·44	1·29	0·98	0·61	2·21	0·8
SiO_2, free	61·18 (free + combined)	63·77 (free + combined)	50·31 (free + combined)	0·90	62·6 (free + combined)	17·70	60 (free + combined)
SiO_2, combined				60·7		12·68	
H_2O-	0·71	0·04	0·13	loss on Ign. 7·47	N.D.	5·50	0·5
H_2O+	4·41	2·07	1·60			15·67	3·5
MnO	Trace	0·03	0·12	0·42	—	—	—
BaO	0·04	0·01	—	—	—	—	—
CaO	Nil	5·10	11·91	0·63	0·70	—	3·5
MgO	2·39	2·53	6·24	2·75	0·91	—	3·0
Na_2O	1·60	4·63	1·97	0·61	—	—	2·4
K_2O	2·10	0·48	0·19	3·01	—	—	1·4
S	0·03	0·01	0·29	—	—	—	0·03
P_2O_5	0·13	0·12	0·25	—	—	—	0·15
CO_2	0·02	1·24	—	—	—	—	0·5
Analyst†	I.I.(1)	H.	H.	I.I.(2)	H.	I.I.(3)	

* *Extract from Gold Coast Geological Survey Bull., No. 4.*

† *The analysts who carried out the analyses in this and the following tables were as follows :—*

E. = *E. A. Eldridge, Imperial College of Science, London.*
H. = *H. F. Harwood, Imperial College of Science, London.*
I.I. (1) = *Miss H. Bennett, Imperial Institute, London.*
I.I. (2) = *W. O. R. Wynn, Imperial Institute, London.*
I.I. (3) = *L. C. Chadwick, Imperial Institute, London.*
I.I. (4) = *H. J. Broughton, Imperial Institute, London.*
I.I. (5) = *W. H. Bennett, Imperial Institute, London.*
T. = *L. S. Theobold, Imperial College of Science, London.*

Ref. No.	Locality.	Description of Sample.
18787	Bobwa Su, Yenahin Group	Phyllite (Birrimian).
8137	Sekondi-Kumasi Railway, m.30.4.	Keratophyre.
7555	Near Akwadum, Sefwi, W.P.	Metabasalt.
2047	Kumasi-Ejura Motor Road, m.58.	Green shale (Voltaian).
6365	Lamassa, Salaga District, N.T.	Chocolate ferruginous clay-shale (Voltaian).
19051	Hill I, shaft 40, Yenahin Group.	Soil.
A	Probable average composition of original rocks.	

Composition at Various Stages in the Formation of Bauxite.

Ref No.	19202	19199	19198	19155	19178-19195	21522-21618	B*
Al_2O_3	43·20	50·64	52·46	54·53	49·14	48·72	58·56
Fe_2O_3	0·91	0·90	6·24	11·48	20·68	21·53	11·56
FeO	0·10	—	—	—	—	—	—
TiO_2	1·21	0·98	2·16	2·38	2·58	3·85	1·85
SiO_2	36·34	23·78	12·84	1·11	1·03	1·02	1·16
H_2O-	0·48	0·58	0·78	1·35	1·08	1·24	—
H_2O+	14·52	22·17	25·01	29·17	24·92	23·02	26·48
BaO	0·03	—	—	—	—	—	—
CaO	Nil	—	—	—	—	—	0·6
MgO	0·28	—	—	—	—	—	0·3
Na_2O	0·74	—	—	—	—	—	—
K_2O	2·12	—	—	—	—	—	—
S	0·01	—	—	—	—	—	—
P_2O_5	0·03	—	—	—	—	—	—
CO_2	0·05	—	—	—	—	—	—
Analyst †	I.I.(1)	I.I.(3)	I.I.(3)	I.I.(4)	I.I.(3)	I.I.(4)	

* *Extract from Gold Coast Geological Survey Bull., No. 1.*

† *See footnote to foregoing table.*

Ref. No.	Locality.	Description of Sample.
19202	Hill 1, shaft 10, depth 38 ft., Yenahin Group.	Pink and cream banded lithomarge.
19199	Hill 1, shaft 10, depth 38 ft., Yenahin Group.	Cream oolitic bauxite nodule in lithomarge.
19198	Hill 1, shaft 10, depth 36 ft., Yenahin Group.	Hard replacement bands of siliceous bauxite.
19155	Hill 1, shaft 10, depth 34 ft., Yenahin Group.	Bauxite, soft yellow brick type with ferruginous inclusions.
19178-95	Hill 1, shaft 10, top 34 ft., Yenahin Group.	Bulk sample of bauxite.
21522-21618	Nsisreso	Bulk sample of bauxite.
B	Mt. Ejuanema, Kwahu.	Mean of 27 analyses of bauxite.

By recalculating each constituent as a percentage of the original amount present, it is found that the mean concentrations of iron, alumina and titanium are increased to about 2¾ times and water nine times their original values. Silica is reduced to well under two per cent. of the original amount present.

Calculations based on the amount of silica dissolved and present-day rainfall and salinity of waters suggest that time of the order of a geological epoch is involved in the formation of the bauxite. Since the bauxite was formed the country has been dissected to a depth of some 1,500 ft., only small remnants of the bauxite peneplane remaining. Thus it seems quite likely that the Gold Coast bauxite is of Tertiary age. The regional geology of West Africa lends support to this view.

Microscopical Characters

Thin sections of the common porous brick types of bauxite show a semi-amorphous cloudy coloured paste with iron hydrate, mostly limonite though possibly with some goethite. Fine prismatic crystals of gibbsite occur in clusters and lining cavities, whilst in pisolitic varieties they may be seen surrounding the pisolitic grains with alternations of thin concentric ferruginous bands.

The more highly-refined type of cream compact bauxite, as found in certain swampy hollows, shows a rather cloudy groundmass of gibbsite, not perfectly crystallised, with numerous inclusions of red iron oxide, and very small highly-refracting prisms (0·01 mm. in length) and acicular crystals of (?) diaspore. Some of these show the characteristic habit of this mineral, whilst others have a distinctly positive principal axis, and so may be böehmite. There are also residual grains of zircon, ilmenite with leucoxene and probably rutile.

Microscopical examination of crushed bauxite showed, in addition to the above, rare crystals of brookite, and some gold in both rounded and angular grains showing crystal forms. Gold has, in fact, been noted in bauxite from several localities as mentioned later.

Description of the Deposits

Ejuanema[1]

This deposit lies on the summit of Mt. Ejuanema at about 2,500 ft. above sea-level, near the southern edge or escarpment of the Kwahu plateau. It is 1,700 ft. above the railway at Nkawkaw, two miles distant, this station being 112 miles from the port of Accra.

The bauxite is derived from red, purple and grey clay-shales belonging to the Voltaian system, the main thickness of the rocks in that system being, however, sandstones. The Mt. Ejuanema deposit is the only important one derived from these rocks, as, owing to faulting, few of the blocks were so placed that their shale beds came into the lateritised zone after peneplanation. At one end of Ejuanema the whole of the shale has been altered to bauxite, so that this material rests on sandstone. In most places, however, one may see a gradual transition upward from the unaltered shale through lithomarge

[1] See Gold Coast Geological Survey *Bull.*, No. 1, by Sir A. E. Kitson.

with fine bauxite concretions to rubbly bauxite. This, in the upper zones, is cemented into massive boulders and blocks, and in places has been dissolved and reprecipitated in pisolitic form.

There is in most areas some 3 to 5 ft. of overburden consisting of red soil with much fine granular and some nodular ferruginous bauxite.

The following chemical analyses illustrate the various types of bauxite from Mt. Ejuanema :—

Bauxite from Mt. Ejuanema

Ref. No.	4929a	4929	4917	4920	4915	4926	4715	5016	A
SiO_2	16·14	7·35	5·11	1·41	0·81	0·49	0·81	0·27	1·49
Al_2O_3	39·79	53·67	40·12	50·92	56·15	60·38	66·41	72·32	58·45
Fe_2O_3	21·89	9·50	32·43	20·47	12·27	11·23	5·06	3·30	12·02
TiO_2	0·94	0·58	0·97	2·10	2·22	1·39	1·95	2·72	2·01
CaO	—	0·20	—	—	—	—	—	—	0·70 (CaO + MgO)
MgO	—	0·07	—	—	—	—	—	—	
Na_2O	—	Tr.	—	—	—	—	—		
K_2O	—	0·13	—	—	—	—	—	—	—
H_2O	20·96	28·67	21·52	25·27	28·12	26·46	26·17	21·72	25·66
Analyst †	H.	H.	H.	H.	H.	H.	H.	H.	H.

† *See footnote to table on page* 334.

Ref. No.	Locality.	Description of sample.
4929a	Mt. Ejuanema	Core of bauxite in circulating channel through shale.
4929	Mt. Ejuanema.	Ferruginous clay-shale altering to bauxite
4917	Mt. Ejuanema, shaft 36.	Ferruginous medium dark red cavernous bauxite.
4920	Mt. Ejuanema, spur 1.	Pisolitic dark red compact bauxite with odd holes.
4915	Mt. Ejuanema, shaft 36.	Yellow and red compact cavernous bauxite.
4926	Mt. Ejuanema.	Grey, pale and dark pink, compact slightly cavernous bauxite.
4715	Mt. Ejuanema, spur 2.	Pale grey and red bauxite.
5016	Mt. Ejuanema, shaft 29.	Oolitic and compact pale yellow and pink bauxite.
A	The mean of 27 analyses, 17 being examples of the various types found, 3 of bulk samples of surface blocks and 7 of samples of various grades found in one shaft.	

There appears to be no regular arrangement of the different grades of ore, and as there is some contamination by inwashed sandy soil near the surface, it was found that in order to produce a good marketable ore, picking and washing were necessary, about one-third of the material being discarded in the process.

A bulk sample of twenty tons of Ejuanema bauxite was tested by the British Aluminium Co., Ltd., who reported it as quite satisfactory for the production of aluminium.

Kitson estimates (*Gold Coast Geol. Surv. Bull.* No. 1) the total quantity of bauxite at 4 million tons, roughly half of which is massive and half rubbly.

Sefwi Bekwai

These deposits occur on the Affoh group of hills north of the town of Sefwi Bekwai, some 55 miles west of the Gold Coast Railway at Dunkwa, which is 98 miles from Takoradi Harbour.

The deposits were discovered in 1921 and subsequently examined in some detail by officers of the Geological Survey. The bauxite varies in thickness from 20 to over 60 ft., forming a capping to the hills and their saddles at between 1,000 and 1,800 ft. altitude (cliffs of 30 ft. to 40 ft. high occur round the summits). The bauxite rests on a layer of lithomarge which separates it from the underlying phyllites and slates of Lower Birrimian age. These strike at N.55°E. and dip steeply, mainly towards the north-west.

Quartz veins occur in the slates, many being auriferous, some gold from which remains in and beneath the bauxite. Sulphides, particularly pyrite, are commonly developed in the slates, their oxidation forming both sulphuric acid and limonite.

In places fragments of phyllite or slate at the base of the lithomarge are metasomatically replaced by bauxite with the preservation of the original banding or cleavage. Such fragments persist for some distance upwards into the bauxite, but eventually the structure is obliterated by periodic re-precipitation with the formation of pisolites and nodules, etc.

The following analyses give some idea of the various types of bauxite, though the analyses are all of bulk samples from which the highly ferruginous bauxite and iron ore have not been removed.

Bauxite from Sefwi Bekwai

Ref. No.	9250-3	9256-60	9261-3	9278-93
SiO_2	0·44	0·64	0·62	0·45
Al_2O_3	57·47	60·68	61·08	52·07
Fe_2O_3	9·75	4·20	4·10	16·40
TiO_2	1·00	1·11	0·87	1·58
H_2O+	30·18	32·17	32·32	27·80
H_2O-	1·02	0·76	1·05	0·92
CaO	0·18	0·33	0·25	0·16
MgO	—	—	—	0·03
V_2O_3	0·04	0·03	0·02	0·04
Analyst †	H.	H.	H.	E.

† *See footnote to table on page* 334.

Ref. No.	Locality.	Description of Sample.
9250-3	Mt. Supirri, shaft 1, 6 ft.–12 ft.	Bulk sample, orange, pink and red fairly compact bauxite.
9256-60	Mt. Supirri, shaft 1, 19 ft.–27 ft.	Bulk sample, orange and mauve fairly compact bauxite.
9261-3	Mt. Supirri, shaft 1, 29 ft.–32 ft. 6 in.	Average sample of orange, mauve and yellow compact bauxite with relics of phyllite banding.
9278-93	Mt. Supirri, shaft 3, 3 ft.–32 ft.	Bulk sample of red and brown ferruginous bauxite.

Bauxite from Sefwi

Ref. No.	7836-40	7861	7910-14	9410-22	9449-55	9461-74	9523-30	9532-40
SiO_2	1·72	0·75	1·26	0·59	0·44	0·46	1·09	0·59
Al_2O_3	48·73	48·46	51·03	50·60	50·19	52·68	50·24	53·20
Fe_2O_3	21·20	21·57	18·08	19·55	20·20	16·33	18·81	15·52
TiO_2	1·10	1·35	1·14	1·28	1·58	1·26	2·05	0·89
H_2O+	26·21	26·48	27·33	26·95	26·43	27·65	26·64	28·39
H_2O-	0·87	0·97	1·02	0·97	0·92	1·06	1·05	1·07
CaO	0·28	0·13	0·21	0·30	0·14	0·33	0·46	0·21
MgO	0·05	Tr.	—	—	—	0·10	—	0·07
V_2O_5	0·03	0·03	0·04	0·05	0·04	0·04	0·04	0·04
Analyst †	H.	H.	H.	E.	E.	H.	H.	H.

† *See footnote to table on page* 334.

Ref. No.	Locality.	Description of Sample.
7836-40	Hill II, Ichiniso.	Mean of 4 analyses of bulk samples around hill.
7861	Hill III, Kanaiyeribo.	Bulk sample of 30 specimens.
7910-14	Hill IV, Jabopirri.	Mean of 4 analyses of bulk sample.
9410-22	Hill VII, Bokakhirri.	Average sample from 13 bulk samples.
9449-55	Hill E. Afumba.	Average sample from 7 bulk samples.
9461-74	Hill W. Afumba.	Average sample from 14 bulk samples.
9523-30	Angwinyare Boka	Average sample from surface and cliffs.
9532-40	Sumanchichi.	Average sample of 9 bulk samples from traverses across top of hill.

It will be noted that the bulk samples average about 50·5 per cent. alumina and 19 per cent. iron. By sorting and rejecting patches of highly-ferruginous material, which is easily recognised by its colour, the bauxite may be upgraded to 55 per cent. or 60 per cent. alumina.

Some years ago a bulk sample made up of seven tons of bauxite from Mt. Supirri and three tons from Ichiniso was shipped to Scotland and tested by the British Aluminium Co., Ltd., who reported that the ore was satisfactory for the production of aluminium. When collecting this sample, the amount of ferruginous material rejected was 24 per cent. of the whole, so that 76 per cent. of the deposit may be regarded as aluminum ore. No washing was needed and none was given.

As the thickness of these deposits varies from 20 to 60 ft. it was thought that a safe estimate of the quantities of bauxite

available would be obtained by calculations based on an assumed thickness of 20 ft. The following gives the quantities so obtained. The first five hills, in order from east to west, are all in the Affoh group and are connected by saddles. Angwinyare and Sumanchichi are small isolated hills lying further east. The large quantities of ore in the saddles and on the slopes have not been included in the estimates :—

Estimated Quantities of Bauxite in Sefwi

	Area in Acres.	Cu. yds. based on thickness of 20 ft.	Tonnage at 1.75 tons per cu. yd.
Kanaiyeribo	179·0	5,780,000	10,100,000
Ichiniso	193·0	6,220,000	10,900,000
Supirri	49·5	1,600,000	2,800,000
Bokakhirri . . .	75·8	2,450,000	4,300,000
Nfatahun . . .	19·8	640,000	} 3,300,000
Afumba . . .	38·9	1,250,000	
	556·0	17,940,000	31,400,000
Angwinyare . . .	15·1	490,000	860,000
Sumanchichi . . .	3·2	100,000	170,000
Total other Sefwi Hills .	18·3	590,000	1,030,000

Yenahin and Mpesaso, Ashanti

In this area, which forms part of the Bibiani range, there are ten bauxite-capped hills, rising to about 2,400 ft. above sea-level and forming a divide between the Ofin and Tano Rivers. The bauxite occurs as local enrichments of remnants of a highly-dissected laterite-covered plateau composed mainly of Upper Birrimian phyllites and lavas. These trend north-east to north and are mostly steeply dipping. To the west the country falls sharply over metamorphosed rocks, quartz and mica-schists, etc., to the foliated granite and gneissic roof-pendants of the Tano valley. Along the eastern flank of the range there is a thin belt of Tarkwaian rocks with a strong development of conglomerate at the north-west end. Further east, in the Ofin valley, Birrimian phyllites are intruded by foliated biotite-granite.

The bauxite deposits occur over a length of about 20 miles, and are situated 40 miles west of Kumasi, from which motor roads run to each end of the deposits. Kumasi is 165 miles by rail from the deep-sea harbour at Takoradi.

The hill tops are mainly flat with some cliffs at the peripheries. Where there is sufficient soil the bauxite supports

a tall forest growth, but in the centre of most of the hills it is devoid of overburden. Grass meadows occur here, fringed by a belt of scrub where the thin soil cannot bear bigger trees. These meadows form the sources of important streams. In one or two cases, though not generally, shallow depressions are permanently flooded and support a peculiar swamp vegetation. In these areas the reducing conditions have resulted in the leaching of iron and consequent refinement of the bauxite. The resulting ore is usually hard and compact due to a settling down of the original porous brick-like aluminous laterite with a corresponding reduction in thickness. Some of the leached iron is redeposited marginally and, therefore, is removed in the early stages of erosion of a hill. This beneficial effect of erosion is well illustrated in Hill No. 9, the northernmost and least dissected hill of the group. High-grade bauxite is there confined mainly to the narrow spurs, the processes mentioned above not having yet operated to any great extent upon the large central area.

It cannot be too strongly emphasised that bauxite is naturally refined laterite and except in the simple cases described above, no definite rules can be laid down as to the distribution of the various grades in the field. Before any estimate of value can be made, systematic pitting and sampling is necessary. A good deal of this has been done by the present concessionaires, but only on a large framework. It is important to know to what extent the various grades are segregated. This influences the amount of up-grading that can be carried out by selection of large blocks of ground but without any picking. The writer's experience shows that, in general, about 70 per cent. of the bauxite contains 50 per cent. alumina, and about 60 per cent. contains 55 per cent. alumina. There are also important areas containing 64 per cent. alumina and 1·7 per cent. of iron oxide. One such area is under the Asuakwa swamp, near Nsiseram camp on Hill VI, which is part of an old plateau watercourse. Quartz and bauxite gravel occur in the creek-bed which is regarded as post-bauxite in age. Since this was laid down the surrounding country has been dissected to a depth of over 1,000 ft. As previously explained, the reducing swamp waters have caused considerable leaching of iron, a valuable process that might be encouraged by artificial ponding under chemical and biological control.

Whilst the Sefwi deposits are derived from Lower Birrimian phyllites and slates, the Ashanti deposits are derived from the Upper-Birrimian, which contains far more lavas, tuffs and dykes. Bands of quartzites and conglomerates, probably Tarkwaian, also underlie the bauxite and give rise to low-grade siliceous and ferruginous bands, which would be discarded in working the deposits. Transverse faulting has assisted in the dissection of the range and quite small streams have cut deep gorges along these lines.

Very many types of bauxite occur, probably porous brick types prevailing. The following sections give some idea of the variations encountered :—

Hill I, Shaft 1

Thickness. ft.	Types of Bauxite.
3	Red soil.
5	Boulders of deep pink and light red bauxite.
6	Cream and mauve conglomerate type.
14	Purple and cream vermicular ore, more ferriferous at bottom.
1	Purple vermicular ore with much powdery cream infilling.
1	Pink clay with slaty bauxite concretions.
30	

At 35 ft. lithomarge with slaty fragments of bauxite (replacement type). At 40 ft. lithomarge. As these materials grade insensibly one into another, a definite thickness for any one type cannot be given.

Hill II, Shaft 21

Thickness. ft.	Types of Bauxite.
0-48	About 50 per cent. yellow brick.
	About 25 per cent. orange brick.
	About 25 per cent. dense pink and cream bauxite.

Hill III, Shaft 31

Thickness. ft.	in.	Types of Bauxite.
	6	Loose bleached bauxite and black sand.
5	0	Orange and yellow brick with cream inclusions.
	6	Red, purple and cream breccia.
6	6	Orange and yellow brick with white brecciated inclusions.
1	0	Red and purple very ferruginous band.
5	6	Yellow brick and breccia.
3	6	Red and orange ferriferous laminated brick.
10	0	Yellow brick, very good grade.
17	0	Yellow and pale orange brick, with some cream lenticles at 49 ft.
49	6	

Hill V, Shaft 51

Thickness. ft.	in.	Types of Bauxite.
20	0	Yellow flaggy breccia, some red pisolitic matrix.
8	0	Much red ferruginous staining by infiltered water from subsoil.
1	6	Yellow and pink soft clayey bauxitic material.
1	3	Pink and cream lithomarge with pink nodules of bauxite.
30	9	

Hill VI, Shaft 61

Thickness. ft.	in.	Types of Bauxite.
42	0	Red, orange and yellow ferruginous brick types, some quartzose, probably derived from Tarkwaian grit.

The following analyses of bulk samples give a good idea of the deposits. The whole of the material is included in the analyses, but in practice some kind of grading would be employed, as is done, for example, in the case of manganese ores and the segregations of iron ore and highly-ferruginous laterite would be discarded. Owing to the striking colouring of the iron ores little experience would be required to recognise the different grades. It is possible that mechanical grading could be employed in some cases.

Yenahin and Mpesaso Bauxite

Ref. No.	19098-11	19247-71	19304-30
SiO_2	1·27	0·29	0·23
Al_2O_3	46·13	54·59	49·05
Fe_2O_3	25·37	13·24	19·68
TiO_2	1·77	2·82	2·90
P_2O_5	0·13	0·50	0·27
MgO	0·03	Trace?	Trace
CaO	0·11	Trace	Trace
H_2O+	23·71	27·77	26·34
H_2O-	0·81	0·84	0·70
MnO	Nil	N.D.	N.D.
BaO	Trace	Nil	Nil
NiO	Nil	N.D.	N.D.
Analyst †	T.	T.	T.

Ref. No.	Hill.	Shaft.	Depth. ft.	in.
19098–19111	I	6	15–28	0
19247–19271	II	21	0–47	0
19304–19330	III	31	0–49	6

Ref. No.	20564	20584	20657	20723	20783	20800	20853	20891
SiO_2	1·60	3·13	1·46	0·37	0·20	0·29	0·58	0·35
Al_2O_3	42·76	50·78	48·60	44·68	50·59	62·89	55·12	41·40
Fe_2O_3	28·16	16·85	17·95	28·08	18·23	1·16	11·44	30·93
TiO_2	2·28	2·43	5·25	2·62	4·90	5·25	2·02	3·38
H_2O-	1·38	1·93	1·49	1·51	1·84	1·81	0·99	0·74
H_2O+	22·83	23·61	25·17	21·98	24·29	28·32	29·06	22·46
MnO	Trace	Trace	Trace	Trace	Nil	Trace	Nil	Trace
Cr_2O_3	0·01	0·04	0·01	0·04	0·02	0·02	0·02	0·12
V_2O_5	0·01	0·07	0·06	0·12	0·06	0·07	0·05	0·12
Analyst †	I.I.(4)	I.I.(5)	I.I.(5)	I.I.(1)	I.I.(4)	I.I.(5)	I.I.(5)	I.I.(4)

† *See footnote to table on page* 334.

Ref. No.	Locality.	Depth. ft.	Series.
20564	Mt. Aya, shaft S. 4–40	0–35	20557–20563
20584	Mt. Aya, shaft E. 2–30	0–43	20575–20583
20657	Furowie, shaft W. 2–50	0–45	20648–20656
20723	Bepo Tiffi, shaft S. ½–30 E.	0–45	20714–20722
20783	Agogoso, shaft S. 2–60	0–35	20775–20782
20800	Nsiseram, shaft 0–50	0–20	20796–20799
20853	Afeduom Hill, shaft 2	25–55	20847–20853
20891	Afeduom Hill, shaft III N. (2)	0–30	20885–20890

In the field a rough guide to the alumina content of a bauxite may be obtained from a determination of the content of ferric oxide and substitution in the following equation :—

$$\frac{Al_2O_3}{70} + \frac{Fe_2O_3}{85} = 1$$

Results so obtained were found to be within 2 per cent. for 85 per cent. of the analyses and within 4 per cent. for 98 per cent. of the analyses.

Manganiferous phyllites are quite common in the Upper Birrimian, so one would expect the laterite derived therefrom to be manganiferous. Such is the case and belts of manganiferous bauxite may be traced without difficulty. On Hill VI such bauxite passes northward down the slope of a long spur through more ferruginous manganiferous laterite to a deposit of manganese ore.

It is very probable that systematic assaying during the development of the deposits would reveal the presence of some gold-bearing quartz reefs underlying the bauxite. Gold has been worked by natives along the flanks of the range and the Upper Birrimian rocks, of which it is composed, are known to contain auriferous reefs. The well-known Bibiani mine occurs in the same belt only some 20 miles to the south-west.

Small streams like the Agogo Su could be made to run small plants for mining purposes, but for any large water-power requirements it would be necessary to go to the Tano river 40 to 50 miles away where some 50,000 horse-power is theoretically available. It seems probable, however, that producer gas would be more economical, as firewood is plentiful and in any case large areas would have to be cleared of forest.

The following estimate is based on an assumed thickness of 20 ft. of bauxite and a weight of 1·75 tons per cubic yard over all except such areas as are definitely known to be too ferruginous :—

Estimated Quantity of Bauxite in Yenahin and Mpesaso

	Million tons.
Hill I . .	11
II . .	9
III . .	7
IV . .	poor grade, not surveyed.
V . .	13
VI . .	86
VII . .	23
VIII . .	15
IX . .	4
	Total 168

In addition to the above, there are very large quantities of broken ore round the slopes and in stream courses, whilst terraces carry important bodies of high-grade ore. A notable example of this last is that of the Boni river, near Nyinatasi camp, south of Mt. Aya.

Asafo, N.W. Sefwi

The Nsisreso bauxite deposit lies on the summit of a sharp range east of the Bia river, 5 miles N.E. of Asempanaiye. It occurs at the southern end of the range and extends eastward along a spur, over a total length of about 3 miles. The elevation is 1,800 ft. above sea-level and the locality is 45 miles north-west of the Affoh group near Sefwi Bekwai.

The deposit has not been pitted as others have, but exposures in cliffs are from 25 to 38 ft. so that it was felt that an assumed thickness of 20 ft. and 1·75 tons per cubic yard would give a fair estimate of quantity, as in the case of other deposits.

500 samples collected along the sides of 1,000 ft. squares were collected and graded by inspection, the result being as follows :—

Grade.	Per cent.	Description.
A	2	Best hard cream ore.
a	24	Good hard pink ore.
b	39	Fairly good to medium orange brick type.
c	24	Red ferruginous low-grade ore.
d	11	Iron ore.

A bulk sample of *a*, *b* and *c* was analysed and gave the following percentage results :—

Al_2O_3	Fe_2O_3	SiO_2	TiO_2	H_2O-	H_2O+
48·72	21·53	1·02	3·85	1·24	23·02

The total quantity is estimated at 24 million tons and the following is a rough estimate of the quantities of the various grades present :—

Per cent. of whole.	Quantity.	Al_2O_3	Fe_2O_3.
89	22 million tons	48·7	21·5
82	20 " "	50	20
60	15 " "	55	14

The ore is somewhat high in iron, which acts as dead weight, but the silica content is low and the ore would be very suitable for the production of aluminium. As on the Ashanti deposits, there is a large meadow in the centre, some half a mile long and surrounded by thin scrub. Thus, 15 per cent. of the whole deposit, or since the meadow covers the better-grade portions, some 20 per cent. of the useful ore is practically free from overburden.

Other Occurrences of Bauxite

Many other hills which are remnants of the highest peneplane in the Colony carry a considerable thickness of laterite. Some of this is not sufficiently refined to be regarded as bauxite and in other cases erosion has left but little of the original cap.

The hills Angwinyare and Sumanchichi in Sefwi are too small to be considered other than in connection with the Affoh group.

West of Sui in Asafo and in the hills south of Asempanaiye there are large areas of laterite, but these are generally too ferruginous to be classed as bauxite, though in places the grade improves in depth.

Further north-east at Mie Mt. and also in the Impuessu Hills and near Asunsu there are small cappings of bauxite. They are not of economic importance, being of low grade and far from the coast, but they are of interest as being the nothernmost occurrences.

Hills with small remnants of bauxitic laterite occur in the Obuasi district near the railway line, some of it being strikingly pisolitic and gibbsitic.

Economic Considerations

Bauxite is a low-grade ore, which with a tenor of say 54 per cent. Al_2O_3, contains only 28 per cent. of aluminium,

the recoverable metal being generally less than 25 per cent. of the ore by weight. The chief impurities are iron, titanium dioxide and silica which is the most objectionable impurity in aluminium production.

Although areas of high-grade ore exist, the Gold Coast bauxites are on the average comparatively low in silica and high in iron, with a very high water content.

With the large increase in aeroplane construction and the consequent increase in aluminium consumption for this and other purposes it seems that the exports of bauxite from the Mediterranean countries must come under more rigid political control. Attention will then be directed to the Gold Coast Colony with its fine deep-sea harbour at Takoradi on the Atlantic seaboard. Rail freights would depend upon the scale of operations and would be a matter for arrangement with the Gold Coast Government.

It is usual to adopt some form of up-grading in order to reduce freight charges per unit of metal. By far the commonest is calcination in whole or part to alumina. According to Fox, bauxite loses its water mainly at two temperatures, i.e. 260° and 700° C.—the first being the destruction point of crystalline gibbsite. The Gold Coast bauxites are characteristically gibbsitic, which, although giving them a somewhat lower alumina content than other varieties, might well prove to be a very favourable factor in calcination. It is hoped that experiments in this direction will be made.

The total estimated quantities of bauxite in the four main groups of deposits in the Gold Coast are as follows :—

	Million tons.
Ejuanema . . .	4
Sefwi Bekwai . .	32
Yenahin and Mpesaso .	168
Asafo	22
Total .	226

PRODUCTION, UTILISATION AND MARKETING OF COLUMBITE-TANTALITE MINERALS

DURING the past few years there has been a limited but increasing demand for columbite and tantalite, the former being especially sought for in connection with large scale experimental work in the steel industry. Supplies of these minerals are believed to be more than sufficient to meet the world's immediate requirements, and it is possible that the developments of both new and old uses will enable the market to become firmly established so that the sales of columbite, particularly, may be measured in hundreds of tons of concentrates per annum.

At the present time Australia is the principal producer of tantalite, where it is worked in the Pilbarra district of Western Australia and in various localities in Northern Australia. Among the more important producers may be mentioned Tantalite Ltd., of Adelaide, Messrs. Gitshom & Johnstone, of Mt. Finnis, North Australia, and J. S. Litchfield, of Darwin. The bulk of the world's columbite supplies is obtained from Nigeria, where, until quite recently, the mineral was regarded as an undesirable heavy constituent occurring with tinstone in such well-known mining districts as Jantar, Jos and Kagerko. The material was separated from the tinstone and thrown away into the waste tailings dumps which, however, have since proved a valuable source of the mineral and have already yielded some hundreds of tons of columbite concentrates. It remains, nevertheless, to be seen whether the producers can separate the mineral in sufficient quantities to meet future demands. Other deposits of columbite-tantalite minerals are known to occur in the Union of South Africa, South-West Africa, Uganda, India, Canada, Belgian Congo, and the United States of America.

The material from the Union of South Africa consists largely of tantalite and is obtained principally by the African Mining and Trust Co. (Pty.) Ltd., from weathered pegmatite in the Pietersburg district of the Transvaal.

Detailed production and trade statistics for tantalite and columbite are not usually recorded in official publications, but some indication of the production and exports of these minerals in the chief producing countries is given in Table I (p. 349).

Analyses of certain columbites and tantalites are given in Table II (p. 350).

TABLE I

PRODUCTION AND EXPORTS OF TANTALITE AND COLUMBITE FROM CHIEF PRODUCING COUNTRIES

(*lb.*)

	Western Australia.* (Tantalite.)	Nigeria. (Columbite.)		Union of South Africa.§ (Tantalite and Columbite.)	South-West Africa. (Tantalite.)		United States. (Columbite and Tantalite.)
	Exports.†	Production.	Exports.	Production.	Production.	Exports.	Production or Shipment.
1930	6,600	(*a*)	—	—	—	—	(*a*)
1931	26,900	(*a*)	—	—	—	—	700
1932	22,400	(*a*)	—	—	—	—	390
1933	17,900	7,200	8,400	—	—	—	300
1934	20,200	34,900	309,000	—	661	661	2,675
1935	16,800 ‡	902,720	902,720	19,572	13,448	13,448	(*a*)

* *Production statistics not available.*

† *Exports valued as follows* (*Australian £*): 1930, £1,254; 1931, £2,953; 1932, £2,684; 1933, £2,170; 1934, £2,990.

‡ *Preliminary estimate.*

§ *Export statistics not available.*

(*a*) *Information not available.*

TABLE II

ANALYSES OF COLUMBITE-TANTALITE MINERALS

(*Per cent.*)

		Western Australia.* (Tantalite)		Nigeria.† (Columbite.)		Uganda.† (Columbite.)	(Tantalite.)	South Africa.‡ (Tantalite.)			United States § (Columbite.)	(Tantalite.)
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Columbic oxide	Cb_2O_5	12·38	15·11	57·49	50·64	55·14	23·26	35·00	27·5	29·50	54·09	29·78
Tantalic oxide	Ta_2O_5	69·63	68·65	5·64	12·83	12·90	41·39	31·10	46·4	47·80	18·20	53·28
Iron (calculated as ferrous oxide)	FeO	2·09	1·63	19·14	14·00	10·59	5·14	21·55	15·71	13·80	11·21	6·11
Manganous oxide	MnO	12·71	14·15	2·44	7·15	8·31	8·95	2·95	3·52	4·03	7·07	10·40
Titanium dioxide	TiO_2	0·25	0·40	6·81	9·18	11·67	0·20	6·40	0·37	0·28	—	—
Tin oxide	SnO_2	0·90	0·48	6·17	2·70	0 ·20	15·11	Trace	Trace	Trace	0·10	0·13

* *Analyses of mangano-tantalite from Wodgina, Pilbarra District, by E. S. Simpson.*

† *Analyses made at Imperial Institute by W. H. Bennett.*

‡ *Analyses by South African Government Chemical Services. Sample No. 7 consisted of composite material ready for export Samples 8 and 9 were tantalite crystals from weathered and fresh pegmatites respectively.*

§ *Analyses of material from the Etta Mine, Black Hills, S. Dakota, by W. P. Headdon.*

Tantalite is used principally for the manufacture of metallic tantalum and certain special steels in which it is incorporated as ferro-tantalum. The metal has been recommended for certain plant equipment and chemical apparatus on account of its property of resisting the corrosive action of practically all chemicals, except strong caustic alkalis, fuming sulphuric acid and mixtures containing hydrofluoric acid. "Vacuum hardened tantalum" can be produced in varying degrees of hardness and can be highly polished. It is used for spinnerets, instrument pivots, thimbles, needles, valve plugs, guides, pipe installations, and gaskets, which may be filled with lead, asbestos, rubber, or cork. Another outlet for the metal is afforded by the growing use of tantalum-carbide tool mixtures which are capable of cutting steel of previously unmachinable hardness and of retaining a precision cutting edge at high speeds for long periods. Further details regarding the uses of tantalum and the occurrence of tantalite in various countries of the world will be found in the Imperial Institute report on "Tantalum and Niobium," published in 1930, price 6d.

Until recently, columbite was regarded as a valueless and rather uncommon mineral. Considerable research and investigation, however, appears to have established the fact that the addition of ferro-columbium (containing 50 to 60 per cent. Cb) to chromium-nickel austenitic steels reduces their intergranular corrosion, especially when they are exposed concurrently to elevated temperatures and chemical corrosion. Hitherto, ferro-titanium was the usual addition agent for this purpose. In an interesting paper by F. M. Becket and R. Franks (*Amer. Inst. Min. Met. Eng. Tech. Paper*, No. 519) it was shown that when there was at least ten times as much columbium as carbon present in the chromium-nickel steel, the latter could not be disintegrated after exposure for either long or short periods at all temperatures between 300° C. and 850° C. The steel, moreover, was said to be very resistant to the action of salt spray. Another interesting paper by the same authors bearing on this subject is "Titanium and Columbium in Plain High-chromium Steels" (*Amer. Inst. Min. Met. Eng. Tech. Paper*, No. 506).

In addition to its function of reducing the intergranular corrosion of chromium-nickel steels, and, therefore, improving

their corrosion- and oxidation-resisting properties, columbium is said to combine with carbon in such steels that would otherwise have combined with the chromium, thus making the steels more stable and allowing the chromium to exert its beneficial effects. The softness and ductility of the "18/18" chromium-nickel steels containing ferro-columbium are attributed to these alleged facts.

Further outlets for columbium are in welding-rods for eliminating difficulties in welding chromium-nickel steels, in wireless valves and in the manufacture of columbium cathodes for the electro-determination of copper, zinc, silver and nickel.

With regard to the marketing of columbite-tantalite concentrates there are, at present, no standard specifications of quality, some buyers preferring practically pure tantalite, others require columbite with a minimum of deleterious constituents and still others any mixture of the two minerals (which in certain cases may even contain as much as 40 per cent. tinstone as an impurity) provided the material is amenable to treatment and the price is reasonable. The price may be determined according to the Ta_2O_5 content of the material expressed in units or percentages, the Cb_2O_5 content, or, as is sometimes the case, on the combined Ta_2O_3 and Cb_2O_5 contents, penalties being imposed for undesirable impurities. One buyer in England has stated that he requires tantalum ore with a minimum of 60 per cent. Ta_2O_5, a maximum of 5 per cent. Cb_2O_5 and a maximum of 1 per cent. Sn. Another English buyer is prepared to consider any type of columbite-tantalite concentrate. An American firm quotes the following specification as meeting their requirements :—

	Per cent.
Ta_2O_5	50 minimum
$Ta_2O_5+Cb_2O_5$ . . .	75 ,,
TiO_2	Nil
SnO_2	1 maximum
Cr_2O_3	1 ,,
Combined impurities other than iron and manganese	5 ,,

A German buyer desires material containing a minimum of 35 to 40 per cent. Ta_2O_5, with not more than 1 or 2 per cent. of tin and chromium. In general, it appears that columbite concentrates should contain not less than 55 to 60 per cent. Cb_2O_5, while the tin oxide content should be as low as possible, but not more than 5 or 6 per cent.

Many columbite concentrates contain considerable quantities of tinstone which can be separated by magnetic treatment. In other cases, the tinstone is magnetic and cannot be separated in this way. It does not follow, however, that such material is unsaleable, since the tin may be extracted by chemical methods as tin chloride (for which there is a ready market), provided the price is sufficiently low to permit this to be done profitably.

Columbite and tantalite are the end-members of an isomorphous series comprising all gradations between the columbate and tantalate of iron, although there is usually present variable amounts of manganese, tin and tungsten. The approximate composition of any member of this isomorphous series is indicated by its density, which varies from 5·3 for pure columbite to 7·3 for tantalite. The nearer the approach to the limiting density values, the more nearly does the mineral approximate to one or other of the end-members.

Prices for tantalite and columbite concentrates in Europe and the United States are at present purely nominal and subject to negotiation. They vary very considerably according to the nature and amount of undesirable impurities present, concentrates containing appreciable tinstone, for instance, commanding lower prices than those of higher purity. It is understood, however, that good-quality Australian tantalite has recently been sold in Europe for about £300 per ton delivered. Nigerian columbite is considerably cheaper and is believed to fetch about £70 or more per ton delivered.

NOTES

The Exhibition Galleries.—Since the last number of this BULLETIN was issued the following additions have been made to the Exhibits in the Galleries.

A new diorama has been installed in the Indian Court to illustrate the Mica Industry. The following is a copy of the label describing this exhibit :—

Mica Field, Splitting and Sorting Sheds

" Here is depicted a scene in the Kodarma field of the great mica belt in the province of Bihar and Orissa. This belt, about 12 miles wide, stretches across country for over 60 miles and contains in lenses of coarse-grained rock, large

'books' or blocks of the world's finest ruby mica which is chiefly valued as an insulating material in the electrical industry. Mica also occurs in Northern and Southern India in the Nellore district of the Madras Presidency and in parts of Rajputana, centring round Ajmere-Merwara.

"In the right distance can be seen a mine. The hill has been completely cut through by quarrying, and the head of a shaft with its windlass indicates the underground work now in progress. Further to the right can be seen an old surface working.

"Bullock carts and pack-animals are bringing the crude mica to the splitting and sorting sheds in the foreground. Here the cutters are at work first splitting the 'books' into sheets and then trimming the edges to a bevel with sickles.

"In the centre the trimmed sheets are being sorted and graded for export. On the left lies a dump heap of mica trimmings and other waste.

"India is by far the most important world producer of block mica and mica splittings."

The diorama was designed and constructed in the Imperial Institute Studios, the cost being defrayed by Messrs. The Micanite & Insulators Co., Ltd., Walthamstow.

Associated with the diorama an exhibit has been arranged to show the value of mica as an electric insulator in the domestic flat iron and of micanite in the motor commutator. Starting in the centre with the mica as mined, the exhibit diverges to the left showing successive steps in the electric insulation of the iron. To the right of the exhibit successive processes are shown in the preparation of micanite from mica splittings and shellac and stages in the making of commutator separators and end rings, finishing with the assembled commutator in which the separators and rings can be seen *in situ*. The material for this exhibit has been presented by The Micanite & Insulators Co., Ltd. and The British Thomson-Houston Co., Ltd.

With the aid of materials presented by Messrs. J. H. Vavasseur & Co., Ltd., and The Bombay Co., Ltd., the Ceylon Court has received a new exhibit illustrating the versatility of the coconut in the many uses to which it is turned. With a whole fruit, opened to show husk, shell and kernel, in the centre, the various materials and their manufactures prepared from it radiate out in all directions and comprise fibre bristles and domestic brushes; hard tennis court surfacing; plasterers fibre; mattress fibre and mattress (illustration); coir dust for felting and gardening; yarn and rope, matting and mats; copra, oil, soap, night lights, margarine and poonac (a cattle food); dessicated coconut and confectionery; charcoal; syrup, sugar, spirit (arrack); locally-made articles of coconut wood, basketry and coconut shell utensils.

To the Palestine Court has been added a diorama of an Orange Grove to illustrate the important citrus fruit industry of the country. The following is the descriptive label which is attached to this diorama :—

The Orange Industry

" Orange growing is not only Palestine's agricultural mainstay, but also provides her chief article of export. From November until April, ' Juicy Jaffas ' are a familiar sight in our fruit shops and their succulence, fragrance and flavour have quickly gained for them a prominent place in public esteem. Indeed, their appearance on our home markets is doubly welcome since they arrive at a time when few other Empire oranges are available.

" This diorama shows in the foreground the colourful scene in a Palestine orange grove at harvest time. During this busy season everyone lends a hand in picking the golden fruit, or in sorting, wrapping and packing it for market. Even the youngsters quickly become expert and thus the work in the sun-drenched groves assumes the appearance of a joyous family picnic. On the right is a string of camels laden with cases of oranges and led by an Arab on its way to the port.

" The bulk of the crop is sold to the orange merchants of Jaffa and Haifa and during the season consignments leave these ports by almost every out-going steamer, mainly for the markets of the United Kingdom and Germany."

This diorama was designed and constructed in the Imperial Institute Studios, the cost being defrayed out of a grant made by the Palestine Government.

In the Northern Rhodesia Court has been arranged an exhibit planned on new lines and appropriately named " From Copper Ore to Copper Metal." This exhibit traces by means of photographs and specimens the winning of the ore in the mine through successive stages of crushing, concentration, smelting, electrolytic treatment and refining, up to the finished metal which is 99·95 per cent. pure copper. The material for this exhibit was kindly presented by The British South Africa Company.

To illustrate the utilisation of copper by the home manufacturer, the exhibit is continued to display sections of drawn bars, wire, sheets and tubing, as well as brass and other alloys of copper. These exhibits were kindly donated by Messrs. T. Boulton & Sons, Ltd., North Staffordshire.

To the Animal Products case in the Australian Court has been added an example of Pearl Glue which is now being manufactured in Australia. This form of glue is made by dropping concentrated glue liquor through a nickel sieve at the top of a tower 30 ft. high into a tank containing ice-cold

kerosene oil. The droplets are chilled and set firm. The mixture of oil and glue droplets is run off and the oil drained away for further use. The droplets are then passed over a perforated plate and subjected to a blast of warm air. This quickly dries the moisture out of them, whilst the thin coating of oil that covers the surface of the droplets prevents adhesion till they become dry and hard. Pearl glue takes only a few hours to become thoroughly dry after manufacture as against many days required to dry ordinary cake glue ; it is also more readily mixed with water when required for use.

Through the courtesy of the Colonial Secretary, three exhibits of more than passing interest have recently been added to the Gibraltar Court. The first, a relief model of the Colony made to the scale of 12 in. to the mile and executed in natural colours, gives a complete bird's-eye view of Gibraltar and well illustrates the contours of " the Rock," the layout of the town and harbour, the water catchment area and other interesting features. Another exhibit consists of " Milestones " in the history of Gibraltar—a set of six small heraldic shields depicting the coats-of-arms of persons, royal and otherwise, with whom the history of Gibraltar is linked. The third and perhaps the most interesting of all is a set of three full-sized replicas of the keys of the Water Port Gate, the Chatham Wicket and the Land Port Outer Wicket. These replicas are taken from the actual keys which are handed over to each new Governor on being sworn in and are laid with ceremony at official dinners, following the ancient custom when the actual gates were locked at night and the keys handed to the governor for safe custody.

Colonial Visitors.—The following is a list of officers on home leave from the Colonies who have visited the Institute during the past quarter.

MAY

W. G. BEATON, Veterinary Research Officer, Nigeria.
C. W. F. BOND, Inspector of Mines, Gold Coast.
R. P. DAVIDSON, Agricultural Officer, Uganda.
D. H. DIMES, Veterinary Officer, Tanganyika.
K. E. HERSON, Inspector of Mines, Sierra Leone.
J. J. NOCK, Curator, Hakgala Botanic Gardens, Ceylon.
C. J. W. PITT-SCHENKEL, Asst.-Conservator of Forests, Tanganyika.
E. M. ROPER, Director, Department of Economics and Trade, Sudan.
Captain G. H. SHELSWELL-WHITE, Acting Provincial Commissioner and Assistant Chief Secretary, Zanzibar.
D. W. TRATMAN, C.M.G., Acting Colonial Secretary, Hong Kong.
B. W. WHITFEILD, Government Chemist, Sudan.
Captain L. W. WILSON, District Commissioner, Sierra Leone.

JUNE

S. BRACEWELL, Economic Geologist, Geological Survey, British Guiana.
Dr. F. DIXEY, O.B.E., Director, Geological Survey, Nyasaland.
J. P. EDWARDS, Asst.-Conservator of Forests, Straits Settlement and Federated Malay States.

G. C. GREEN, M.B.E., Asst.-Colonial Secretary, British Guiana
Dr. J. C. HAIGH, Economic Botanist, Ceylon.
T. HIRST, Geologist, Geological Survey, Gold Coast.
H. E. HORNBY, O.B.E., Director of Veterinary Services, Tanganyika
Captain J. R. MACKIE, Asst.-Director of Agriculture, Nigeria
E. F. PECK, Veterinary and Agricultural Officer, British Somaliland.
A. E. POLLARD, Trade Commissioner, East Africa.
N. L. SMITH, Director of Education, Hong Kong.

JULY

W. H. BEETON, District Commissioner, Gold Coast.
B. BUNTING, Agriculturist, Federated Malay States.
G. S. CANSDALE, Asst.-Conservator of Forests, Gold Coast.
Captain C. W. ELLIOTT, M.C., Asst.-Conservator of Forests, Kenya
J. L. FROGGATT, Entomologist, Department of Agriculture, Territory of New Guinea.
S. M. GILBERT, Chief Scientific Officer, Coffee Experimental Station, Tanganyika.
E. L. HAY, Inspector of Plants and Produce, Gold Coast.
E. T. HOLMES, Agricultural Officer, Nigeria.
W. E. HUNT, C.M.G., O.B.E., Chief Commissioner, Nigeria.
E. F. MARTIN, Agricultural Officer, Uganda.
Dr. F. J. MARTIN, Director of Agriculture, Sierra Leone.
E. PARNELL, Government Treasurer, Sarawak.
G. T. PHILPOTT, Tobacco Officer, Department of Agriculture, Uganda.
L. ANGLIN POWELL, Department of Science and Agriculture, Jamaica
A. S. RICHARDSON, Senior Agricultural Officer, Tanganyika.
J. C. W. ROCK, Registrar-General and Director of Commercial Intelligence, Ceylon.
C. F. SYMINGTON, Asst.-Conservator of Forests, Federated Malay States.
F. H. S. WARNEFORD, Superintendent of Agriculture, Antigua, Leeward Islands.
J. LYNE WATT, Agricultural Officer, Department of Agriculture, Kenya.
J. WEST, Botanist, Department of Agriculture, Nigeria.

All Dominion and Colonial officers who may be visiting London are invited to come to the Institute to see our Galleries or to discuss scientific and technical problems in which they are interested.

Development of Agriculture in West Africa.—Mr. F. A. Stockdale, C.M.G., C.B.E., in his capacity as Agricultural Adviser to the Secretary of State for the Colonies, visited Nigeria, Gold Coast and Sierra Leone between October 1935, and February 1936. The report which he presented has now been issued by the Colonial Office as a paper of the Colonial Advisory Council of Agriculture and Animal Health. It forms a very valuable document for all concerned in the development of West African agriculture, and it is only possible here to give a mere outline of the many problems disscussed.

The visit was made, primarily at the request of the Government of the Gold Coast, to consider certain questions concerning the inspection of cacao and other matters of agricultural policy. The opportunity was taken, however, to visit also Nigeria and Sierra Leone.

Despite the period of financial depression, marked progress

was noted in West African agricultural problems. For the future a close co-operation between the different Departments of Agriculture is recommended, by means of exchange visits of officers and a revival of the West African Agricultural Conferences. Attention is drawn to the problems of shifting cultivation and agricultural education and the importance of cacao research is emphasised.

In *Nigeria* improvements in cultivation practices were evident in many areas and increases in exports of palm products, cotton and cacao were expected in the coming season. The system of Produce Inspection, for regulating the quality of exports, was thoroughly investigated. This inspection and grading at established markets has been in operation with cotton since 1926 and was extended to palm products and cacao in 1928, with the result that the quality of these products has been greatly improved and adulteration prevented.

Co-operative Societies have been established to stimulate the production of first-grade cacao and have been encouraged to form themselves into marketing unions. The Union at Ibadan has opened a store where cacao is received from the societies, inspected and marketed; the next advance in co-operation should be the provision of credit facilities, as is done in the Gold Coast.

With increasing population, shifting cultivation must give way to mixed farming, with the use of manures to renew soil fertility. Animal husbandry has been introduced with success, at first on demonstration farms and then among the farmers, who obtain advances from Native Administration funds for the purchase of cattle and implements. Work is going on at experimental stations on soil fertility, the selection of various crops, cultivation under irrigation, cattle breeding and instruction of natives. There are also farm centres where instructional work, seed multiplication and field tests are carried out.

With the increase of mixed farming there is already a need for further veterinary assistance and a greater supply of implements. Irrigation from well water might well be developed also. Suggestions are made regarding the cultivation of ginger in Zaria Province and possible developments in the rather unproductive middle belt of Nigeria.

Work at the Central Experimental Station at Ibadan, Southern Provinces, on green manuring, improvement of the lint qualities of Ishan cotton, citrus trials, oil palm selection, cacao selection and shading, and soil fertility was inspected and discussed. The extension work on rice and oil palms, and the trials with fruit growing and poultry were also considered.

In the *Gold Coast* visits were made to various parts of the Colony, Ashanti and the Northern Territories, inspecting cacao and banana farms, cacao buying centres, the work of Co-operative Societies and other agricultural activities. The progress of animal husbandry and the position and possibilities of citrus cultivation were surveyed.

A detailed study was made of the cacao inspection system. Improvements in drainage, shading and wind-protection are recommended on the farms, although the crop yields are already high. Many farms are mortgaged and the farmers take little interest in the preparation of their produce, in spite of the efforts of the Department of Agriculture and the Co-operative Marketing Societies to secure good-quality cacao. Voluntary inspection, chiefly at the ports, was started in 1927 and since 1934 the export of wet or inferior cacao has been prohibited.

The need for inspection is shown by the fact that about 4 per cent. of the total crop was rejected in the season 1934-5. Native producers favour inspection carried out at the ports, but many buyers are against it, preferring a system where producers are penalised for tendering wet cacao. Such a system is to be recommended, but to be successful it requires efficient inspection up-country. Buyers are also against grading, nevertheless, it is recommended that a system of inspection and grading should be developed and that buyers should be authorised to employ approved graders; further that rejected cacao should be exported marked as such and not mixed with high-quality produce to give an average grade. In this connection an Advisory Board should be set up, with representatives of buyers and producers.

The possibility of establishing a banana industry in the Gold Coast was considered in the light of recent trials and it is recommended that the Government should support further work. As facilities for ocean transport are necessary, these trials have been centred around Takoradi, but the soils in that region are unsatisfactory and there have been losses, partly owing to the heavy freight on small bunches of bananas with a relatively high proportion of stalk. Before further attempts are made it is emphasised that a soil survey of the region should be made by Agricultural Officers. The production of larger-sized bunches and reductions in cost of freight and marketing should be aimed at. While Gros Michel might be financially a more satisfactory variety than the Cavendish, it requires a greater depth of soil and does not succeed in exposed situations.

A survey was made of the oil palm industry, in which further development is possible, the local consumption of the oil being large, although little is exported. The present need

for restricted planting of limes is realised and the coconut industry is increasing now that copra-drying difficulties have been overcome. Rice, coffee, tobacco and citrus were reviewed.

Development is held up both in the Accra Plains and the Northern Territories by inadequate water supply. When this problem has been solved the introduction of mixed farming and the establishment of a central experimental station at Tamale should do much to develop the region. In this work much will depend on the co-operation which is achieved between both individuals and departments.

The co-operative movement, of which a detailed review was made, was originally based on an improvement of marketing and better preparation of produce, but is now more concerned with finance of thrift and credit. With this advance it is recommended that a special group of officers be appointed to take charge of co-operative duties, which clearly cannot be maintained by the District Agricultural Officers.

In conclusion, it is emphasised that one of the first duties of the Department of Agriculture should be to assist the cacao industry by considering both immediate agricultural problems and the requirements of the future, in establishing a central experimental station to investigate cultural operations and new strains. The problem of shifting cultivation also requires careful investigation.

As regards *Sierra Leone,* from a general review of the agriculture of the colony definite progress can be reported, notably in the rice industry. Rice is now being produced in quantities exceeding the local consumption and an increasing export is to be expected. Trials with cattle cultivation are recommended in the Scarcies area and it is suggested that Co-operative Societies might be developed in connection with the industry. The general success of the Produce Inspection system is noteworthy. In a general consideration of agricultural policy the development of rice cultivation takes an important place and it is suggested that animal husbandry and poultry keeping should be given attention. Other subjects reviewed in the Sierra Leone section of the report include the work being carried out at Njala Agricultural Station, Masanki Oil Palm Plantation, Newton Fruit Farm and the subject of Agricultural Education.

The Marketing of Tung Nuts.—For some years past efforts have been made under the auspices of the Imperial Institute Advisory Committee on Oils and Oilseeds to encourage the production of tung oil in the Empire. To this end a special Sub-Committee was appointed in 1929, among its members being representatives of the Royal Botanic Gardens, Kew, and the Research Association of British Paint, Colour and

Varnish Manufacturers, as well as of the Imperial Institute. Besides assisting in the starting of experimental cultivation trials by the distribution of seed and by the dissemination of related information, the Sub-Committee has been engaged in the investigation of various problems, the elucidation of which contributes to the success of this enterprise.

The progress that was made during the first few years of the experimental trials was summarised in an article which appeared in this BULLETIN, 1932, **30**, 24 and reports on the examination of nuts produced in various parts of the Empire have also been published (1932, **30**, 271; 1933, **31**, 327).

Although the results of the experiments have shown that tung trees will grow in many parts of the Empire and will yield tung oil of excellent quality, the production of nuts on a really large scale has not yet been reached in any part of the Empire. The relatively small quantities of nuts that are now becoming available as the trees mature may not be easy to dispose of in certain cases unless some special arrangement is made for handling them. With this end in view the Sub-Committee has arranged for a London firm to buy the nuts, in lots of not less than one ton at a fixed scale of charges and the various Government Departments and private individuals in the thirty or so different countries concerned have been informed accordingly. The letter which was despatched on June 15, 1936, by the Secretary of the Sub-Committee was in the following terms.

"The Imperial Institute is aware that during the last few years you have been carrying out experimental trials in the cultivation of tung trees. It is anticipated that by this time your trees are probably producing fruits and that you may be harvesting a crop large enough for you to be desirous of offering the nuts for sale on the market.

"In this connection the Imperial Institute foresees that you may experience some difficulty in disposing of your crop until such time as tung nuts have become a regular article of commerce. In order to overcome this difficulty and to assist growers to sell their produce the Imperial Institute Sub-Committee on Tung Oil has made an arrangement with Tung Oil Estates Ltd., Tavistock House (North), Tavistock Square, London, W.C.1, whereby the Company is prepared to pay the grower for quantities of tung nuts, of not less than one ton lots, c.i.f. United Kingdom port, the following prices per ton based on the London spot price of oil per ton at a date two months after leaving the port of shipment:—

London spot price of Tung Oil per ton. £ s. d.	Price payable for Tung Nuts of fair average quality per ton c.i.f. United Kingdom port. £ s. d.
45 0 0	9 0 0
55 0 0	11 0 0
65 0 0	13 0 0
75 0 0	15 0 0
95 0 0	19 0 0

"When the price of tung oil varies between the above prices the nuts will be paid for *pro rata*.

"The above-mentioned prices will be applicable for twelve months from the date of issue of this letter, after which they will be reviewed from the experience obtained.

"This offer is made for tung nuts and not for the fruits. The husks should therefore be removed from the fruits before shipment and only the nuts, complete with their thin woody shells, forwarded to the firm mentioned. The nuts should not be more than 6 months old.

"If you should desire to avail yourself of this arrangement you are asked to communicate direct with Tung Oil Estates Ltd., who will furnish you with details as to shipment. When writing to the Company the species of tung grown should be stated, i.e. either *Aleurites Fordii* or *Aleurites montana*.

"In the event of your not having 1 ton of nuts for disposal it might be possible for you to co-operate with other growers in your district and to combine the produce from the respective estates with a view to the collection of a total quantity of at least 1 ton of nuts. *A. Fordii* nuts should not be mixed with those of *A. montana*.

"My Committee desires to keep in touch with all developments in connection with the tung industry and I shall therefore be glad if you will kindly inform me of any action you may decide to take in connection with the above offer."

Laurel (Berry) Oil.—Laurel oil is obtained from the berries of the tree *Laurus nobilis*, which occurs in the countries bordering the Mediterranean, but at present the production of the oil appears to be confined to Italy.

The berries consist of 70 per cent. kernel and 30 per cent. pulpy pericarp, both of which contain oil. The kernel of the fresh berries is recorded [1] to contain about 13 per cent. of oil and the pulp about 26 per cent. Collin and Hilditch [2], who apparently examined dried material, state that the kernel contains about 16 to 17 per cent. of a pale yellow, solid fat, while the pulp contains 35 to 37 per cent. of a green fatty oil.

Commercially it is not practicable to extract the pulp and the kernels separately and the whole fruit is, therefore, treated. The composition of the commercial oil obtained is dependent on the method of treatment adopted. It is understood that in Italy the berries are boiled with water for at least ten hours, the liquid then poured off and allowed to settle. The oil which rises to the surface is skimmed off and after removal of any water, is stored in jars. This method, though simple, gives a yield of only 8 to 10 per cent. of oil, consisting mainly of the pulp oil, most of the kernel oil remaining in the berries.

If instead of using this method the oil is extracted, by first crushing the berries and then removing the oil either by pressing or solvent extraction, a considerably higher yield is obtained. The resultant product which consists of both

pulp and kernel oils will, of course, differ from that obtained by the previous method.

The table given below records some of the principal constants of the pulp and kernel oils, the oil obtained by the boiling method and the expressed oil.

	Pericarp oil [1].	Kernel oil [1].	Oil obtained by boiling method [1].	Expressed oil [2].
Specific gravity at 15° C.	0·9284	—	0·926	—
Melting point ° C.		33	32–36	
Solidifying point ° C.	—	10	24–25	—
Saponification value	188	219	205	269·8
Iodine value	88	71·2	74·5	86·4
Unsaponifiable matter, per cent.	—	0·75	—	6·2

The following table shows the composition of the oils [4].

PERCENTAGE COMPOSITION OF FATTY ACIDS

	Pericarp.	Kernel.	Whole Fruit.
Lauric	3	43	30–35
Palmitic	20	6	10–11
Oleic	50–60	32	36–40
Linolic	15–22	18	18·5–19

Laurel oil possesses stimulant and antiseptic properties and is used in veterinary medicine both internally and for external application. The oil is seldom used internally in the case of human beings, but may be incorporated in various types of embrocations.

Laurel oil can be used for the manufacture of soap and it is understood that a high quality green soap of the "palm-olive" type is produced in Italy. If processed separately the pulp oil yields a green antiseptic soap, whilst the kernel fat forms a white free-lathering soap.

The residue from the berries after extraction of the oil is said [1], [3] to be quite suitable for feeding to cattle and horses. In this connection the following analyses of the pericarp and kernel may be quoted [1].

	Pulp *Per cent.*	Kernel *Per cent.*
Moisture	27	32
Fat	26·15	12·9
Crude protein	7	5·4
Fibre	25	7·25
N-free extract	10·43	42
Ash	3·5	0·95

Assuming that the residue, after expression of the oil, contains 10 per cent. moisture and 7 per cent. fat, it would have approximately the following composition based on the foregoing figures.

	Pulp. Per cent.	Kernel. Per cent.	Whole berry. Per cent.
Moisture	10	10	10
Fat	7	7	7
Crude protein	13	8	9·5
Fibre	45	10·5	21
N-free extract	19	63	50
Ash	6	1·5	2·5

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Recent Developments in the Utilisation of Soybean Oil in Paints.—Fifteen years ago soy beans were originally grown in the United States of America as a substitute crop to meet the needs for more legumes, to replace red clover and oats in the rotation and to increase the supplies of home-grown feeds of high protein content. At the present time soy beans constitute one of the more important crops under cultivation in that country. In the early days the beans produced were all utilised for feeding purposes and for seed with which to plant the expanding acreage under this crop. Not until 1929 did the use of soy beans as a source of oil become a potent factor influencing the production of the crop and by 1934 such marked advances had been made that nearly 21,000,000 lb. of soybean oil were used in the manufacture of food products and for industrial purposes.

Among the industrial uses to which soybean oil has been put its utilisation in paint and varnish manufacture occupies an important position, over 10,000,000 lb. being consumed for this purpose in 1934. The Illinois Agricultural Experimental Station was among those responsible for the adoption of soybean oil as a paint oil. An account of the experimental trials made at the Station with this material is given in the Station's *Circular* No. 438. These trials were started in 1930 when paints were tested in which soybean oil constituted varying proportions up to 50 per cent. of the total vehicle used in the paint. The object of the tests was to study the behaviour of paints differing primarily in their content of

raw and treated soybean oil and to compare the effectiveness of different driers. Direct comparisons were made with standard linseed oil paints. After five years' exposure the paints made with soybean oil were found to be very satisfactory.

Experiments were also started in 1931 with paints intended for interior work. The results were very promising and further trials were made. Rooms in the agricultural buildings of the University of Illinois were decorated with soybean paint and after three years the paint was in excellent condition. Other buildings near the University were also painted with soybean paints and were found to be in good order after two years.

From the exposure and other tests which have been made, it is concluded that soybean oil should find a permanent place in the manufacture of paint. The results support the findings of other investigators that 30 per cent. and more of the oil component of paints may without disadvantage consist of suitably treated soybean oil provided that the correct driers are used. This conclusion is supported by results that are being obtained in outside work. Soybean oil paint has been used on many farm buildings in Illinois and has been found to give satisfactory results. The American paint industry also agrees that soybean oil can be satisfactorily employed as a paint oil, while the Ford Motor Company plans to increase the amount of this oil used in enamel for their motor cars.

Sisal in Madagascar.—The following account of the position of the sisal industry in Madagascar is translated from an article on sisal in *La Revue de Madagascar* for April 1936.

The first trials with sisal in Madagascar were carried out in the Comoro Islands and a little later in the districts of Diego-Suarez, Tuléar and Fort Dauphin. Some trials were made on the East Coast, but in that area the limited amount of level ground is occupied by coffee plantations. On the West Coast, sisal plantations were started on a modest scale with plants imported from East Africa: they were gradually extended in accordance with the available supply of suckers and bulbils from the earlier plants.

Madagascar sisal is exported entirely to France. Experts class it as of very good quality and this is confirmed by the price obtained. The lowering of market values unfortunately occurred just when most of the plantations were starting to produce and in place of the profits which had been expected the sale of the small quantities available was carried out at a loss. All concerned ceased work and they would have entirely given up operations but for the introduction in March 1931

of a duty of 10 centimes per kilogram on sisal imported into France, imposed for the benefit of Colonial producers, which filled the gap between the price of production and the price of sale. The confidence of the planters returned and they were able to extend their plantations.

Apart from this, serious attempts have been made to lower the price of production. The factories are now provided with large-scale modern equipment and the methods of cultivation have been perfected by using machines drawn by animals. The result is that a noticeable diminution of expense can be observed, together with better yields. On the other hand the cost of transport is a heavy burden on the production of sisal in Madagascar. The plantations have been established in the interior, sometimes nearly 100 kilometres from the port of shipment, in order to make use of fairly large areas of suitable soil. The transport to the coast costs 75 to 100 francs per ton and with the cost of loading, freight and various expenses, the product sustains a charge of from 350 to 400 francs. In spite of these obstacles the production of sisal in Madagascar continues to progress. The exports in 1924 were only 72 tons, but in 1933 they amounted to 1,012 tons; in 1934 to 1,914 tons; and in 1935 to 2,236 tons, valued at 2,459,000 francs.

The total production of sisal in the French Colonies hardly exceeds 6,000 tons, whilst the annual consumption in France is about 35,000 tons. The fibre is thus assured of a ready outlet in the Mother Country. It is one of the products which can be subjected to a policy of economic preference and for which there are still large possibilities of development in the French Colonies.

Prevention of Cotton Worm.—The Royal Agricultural Society of Egypt is offering a reward of £E20,000 to the first inventor of a method for preventing the cotton worm (*Prodenia litura* Fabr.) from infesting cotton plants. Among the conditions are the following:—

(*a*) The method must be of such a nature that after its application neither the egg masses nor the larvæ of the insects appear on the cotton plants.

(*b*) The method must protect the plants against the attacks of the worm without being in any way injurious to agricultural products, human beings or animals. Its application must not be so difficult that the cost would absorb any considerable proportion of the value of the crop.

(*c*) Competitors must belong to a recognised body of scientific workers, or must be represented by a recognised public or scientific institution in Egypt or elsewhere.

(*d*) Any method which the Society decides to consider as possibly deserving the prize will be subjected to trial for a period of six years and, if thought advisable by the Society, for a seventh year. If at the end of the trials the method is recognised by the Administrative Council of the Society as effective, the prize will be immediately paid to the inventor.

(*e*) If the method finally recognised as effective has been put forward by two or more individuals under the prescribed conditions, the Society reserves the right to divide the prize between the successful competitors according to their merits and in such proportion as may be considered suitable.

(*f*) Applications to participate in the competition must be submitted within the next twelve months.

Further particulars and a form of declaration can be obtained from the Society at Cairo, either direct or through the Royal Egyptian Consulate, 26 South Street, London, W.1.

Wheat in 1935.—According to information received from the International Institute of Agriculture the world wheat crop of 1935, excluding that of Russia, China, Turkey, Iran and Irak, was one of the smallest harvested since 1924. It was only 1 per cent. larger than the very small out-turn of 1934 and 8 million metric tons short of the average production obtained in the five years 1929 to 1933. The 1935 wheat year has one feature in common with 1934 in that poor results were recorded in all the important exporting countries. The total production in 1935 is estimated to be 54·9 million metric tons, which is 16 per cent. below the quinquennial average. The reduction is the outcome of the damage resulting from rust in the United States and from drought in Australia, Argentina, the Danube countries and North Africa. Harvests in the importing countries, however, were plentiful, out-turn being equal to that of 1934 and 9 per cent. above the average. The preliminary estimate of the crop of the U.S.S.R., which, however, may differ widely from the final returns, indicates a production of 31·3 million metric tons or 900,000 metric tons larger than the crop of 1934. This estimate, considered with the increase in exports which has occurred this year, confirms that wheat production in Russia was plentiful. The crop of China on the other hand is said to be 15 to 20 per cent. smaller than the yield of 1934 owing to drought in the north and to floods in Central China.

The exportable wheat supplies of the year 1935-36 are estimated to be 20·5 million metric tons, the lowest figure of the past-War period; it is 16 per cent. smaller than that of the previous year which was itself a low record and 45 per cent. below the high record of 1928-29. These supplies consist

of 10 million metric tons carried over from previous harvests and about 10·5 millions of 1935 crop.

The probable requirements of the importing countries are placed at 14·7 million metric tons. The statistics of commercial wheat movements of the first half of the current season show that the net wheat exports of all the exporting countries were 7·1 million metric tons and thus even smaller than the reduced shipments of the previous year. European wheat imports during the same period were 4·9 million metric tons against 5 millions in the preceding year and thus constitute a low record.

The reduced world wheat demand, as revealed by the commercial movements of the first six months of the year, is, according to the International Institute, the result not only of the plentiful internal supplies of wheat and other food products in the importing countries, but also, to a large extent, of the political and financial situation which obstructs the movement of goods, labour and capital.

If the probable requirements of the importing countries (14·7 million metric tons) are compared with the exportable supplies of the surplus-producing countries, it is seen that the exportable surplus of the 1935 crop (10·5 million metric tons) will meet only two-thirds of the probable world demand. To fill the gap, it will be necessary to draw 4·2 million metric tons from the old crop stocks, which on August 1 amounted to about 10 million metric tons.

Exportable stocks on August 1, 1936, will thus hardly reach 5·8 million metric tons, which is lower than the normal level of the pre-crisis period.

Selenium Poisoning of Crops and Stock.—As long ago as 1860, a disease of horses, which was attributed to some poisonous effect of the pasturage, was observed in South Dakota. A similar disease affecting stock has been known in various districts in the United States since that time, but it is only during the past three or four years that definite evidence has been obtained as to the real cause of the trouble, and it is now considered as proved that this disease is due to the poisoning of stock by pasture plants containing selenium. A considerable amount of work on the occurrence of selenium in soils and crops has been carried out in the United States and is still in progress (*U.S. Dep. Agric. Bur. Chem. Soils, Rep.*, 1935, p. 35). The main conclusions so far reached are outlined below.

The presence of selenium in soils may have one of two effects on agriculture. In the case of permanent pasture on seleniferous soils, the main effect is indirect; the plants absorb selenium from the soil and this seleniferous vegetation

poisons stock, especially young stock, grazing on it. This has been the major result observed, as owing to low rainfall and other conditions, the greater part of the area of known seleniferous soils in the United States is occupied by permanent pasture. With arable soils containing selenium, there may be a direct toxic effect on the crop-plants grown and this crop may also cause poisoning of stock fed on it. Owing to the relatively small quantity of food-stuffs for human consumption grown on seleniferous soils, no cases of poisoning of human beings due to this cause appear to have been recorded.

The areas giving rise to seleniferous vegetation in the United States are of considerable extent and occur in several States, although the limits of any such area have not yet been defined. The selenium in the soils of these areas is believed to be derived from sulphide minerals occurring in the soil parent materials, which, in most cases, appear to be Cretaceous shales. The soils formed from such seleniferous materials apparently contain enough selenium to produce toxic vegetation when the mean annual rainfall is insufficient to permit it to escape by percolation and they are, therefore, most liable to occur in arid regions. This may be a point of considerable importance in considering irrigation schemes for such districts. The selenium in these soils is not uniformly distributed either in the surface soils of an affected area or throughout the soil profile.

The amounts of selenium absorbed from seleniferous soils by plants vary considerably and are apparently dependent not only on the amount of selenium present in the soil, but also on the kind of plant, some species absorbing much larger quantities of selenium than others from the same soil. The composition of the soil, especially the amount of available sulphur and the ratio of available sulphur to selenium, is of great importance in relation to the toxic effect of seleniferous soils on crop plants. The different portions of a plant also contain varying amounts of selenium and this would affect the toxicity of the plant to stock. Evidence shows that where pastures are not over-stocked, so that the animals grazing them are free to choose certain portions of the vegetation and to reject others, those plants which absorb the largest quantities of selenium from the soil tend to be rejected by the grazing stock.

It is considered probable that variation in seasonal rainfall will have an effect on the absorption of selenium by plants, but this point is not yet settled, as it happens that during the progress of the present work the seasons have been particularly dry.

This question of seleniferous soils and vegetation is of

considerable importance in the drier parts of the United States and may also be important in arid regions in other countries.

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Occurrence of Selenium in Natural and Manufactured Phosphates.—In consequence of the recently discovered importance of selenium as a toxic element for crops and stock (see this BULLETIN, p. 368), attention has been drawn to the possibility that selenium may be added to the soil as a minor and unintentional constituent of artificial manures. As the amounts of selenium necessary to produce toxic effects are very low, the continued use of a fertiliser containing even small quantities of this element might prove harmful, especially as artificial manures are usually incorporated with a relatively shallow depth of soil, which is normally that mainly occupied by the roots of crop plants.

As a result of these considerations a comprehensive study has been made, by the United States Bureau of Chemistry and Soils, of the selenium content of a large number of natural phosphate rocks from deposits situated in various parts of the world, and also, in a few instances, of that of manufactured superphosphate and phosphoric acid. ("Occurrence of selenium in natural phosphates, superphosphates and phosphoric acid," by L. F. Rader and W. L. Hill, *J. Agric. Res.*, 1935, **51**, 1071). In this work, it was found that the selenium content of natural phosphates ranges from less than 0·1 part per million in a Tennessee brown rock phosphate to 55 parts per million in Wyoming and Algerian phosphates. The phosphates of Ocean, Nauru and Makatea Is. all contain less than 1 part per million of selenium.

The selenium in natural phosphates appears to be associated mainly with organic matter and to a smaller extent with inorganic sulphides. Geologically, primary deposits of phosphates are, in general, richer in selenium than secondary deposits, while deposits belonging to the Permian and Cretaceous ages contain the most selenium. The selenium content of phosphate deposits appears to be about the same as that of other sedimentary deposits in the same region.

In the manufactured products which were, in all cases, made from American raw materials, the amount of selenium found in superphosphate was from 0·8 to 4·0 parts per million, and in phosphoric acid manufactured by the sulphuric acid process, was less than 0·5 parts per million. Only a small fraction of the selenium present in the natural materials was found, therefore, in the finished products. The use of superphosphate seems to be without danger, but continued use of large quantities of selenium-bearing phosphate rock might possibly lead, under arid conditions, to a toxic concentration of selenium in the soil, although it is considered probable that under normal conditions the added selenium would be largely leached out by rainfall.

It may be of interest to mention that Stoklasa (Über die Einwirkung des Selens auf den Bau- und Betrieb-stoffwechsel der Pflanze bei Anwesenheit der Radioaktivität der Luft und des Bodens," *Biochem. Z.*, 1922, **130,** 604) reported from 11 to 25 parts per million of selenium in superphosphate and from 15 to 36 parts per million in ammonium sulphate, of European manufacture, the selenium being apparently derived chiefly from the sulphuric acid employed in the processes of manufacture. He considered that the actual amounts of selenium added to and retained by the soil by normal use of these products were too small to have any toxic effect.

Platinum and Allied Metals.—The series of brochures issued by the Imperial Institute under the general title of Reports on the Mineral Industry of the British Empire and Foreign Countries is now being published by the Institute itself. The latest volume in the series, which appeared early in June, is a second edition of "Platinum and Allied Metals" (price 3*s.*, postage 4*d.*). Very little change has been made in the outward appearance of the volume, the familiar grey covers being retained, but a stiff board cover has been substituted for the former paper one. While still retaining its original format, however, the book has been completely rewritten and considerably enlarged.

The publication consists of 137 pages of which the first 39 are devoted to a survey of the properties of this group of metals and the methods used in extracting them from their ores and refining and marketing the products. Their uses are enumerated and world production and prices discussed.

The main body of the book, however, deals with the world's resources of platinum and its allied metals and gives descriptions of the various deposits, country by country, together with statistics concerning production and trade. A useful selected and classified bibliography of 23 pages is appended.

Geological Research in Uganda.—Over a period of years it was customary for the Geological Survey of Uganda to include a series of research notes at the end of its annual report. Latterly these have been styled "Bulletin," and from 1934 onwards the bulletin has been issued as a separate publication. *Bulletin* No. 2 (1935, Government Printer, Entebbe, 84 pp.) contains twelve articles, contributed mainly by officers of the Survey, on a variety of subjects including the following: the geology of the goldfields in those parts of Kenya adjacent to Uganda, viz. Northern and Southern Kavirondo; an account of the petrology of the rocks of the Kilembe copper deposits; gold on the Buhwezu Plateau; criteria indicative of tin-bearing granites as distinct from those devoid of tin deposits; thermal and mineral springs; gravity measurements in East Africa; and a note on the zinc-cup test for cassiterite. In addition there is a short lexicon of Uganda stratigraphy and an appendix bringing up to date the bibliography of the geology of Uganda published last year, features of great value to those who have occasion to refer to the geology of this region.

"A Contribution to the Study of the Geology of Kavirondo," by Dr. K. A. Davies, summarises a considerable amount of both published and unpublished information on the geological succession of Kavirondo (Kenya) and the adjacent part of Uganda (Budama). He concludes that the greater part of the gold so far discovered in eastern Uganda has been shed from the porphyries occurring as dykes and marginal facies of the main granitic intrusions of the Kenya-Uganda Border region. In his opinion, the well-known Kisendo Conglomerate of Northern Kavirondo represents a series later than the Karagwe-Ankolean and one which was formed partly under sedimentary and partly under volcanic conditions. Pebbles of quartz contained in the conglomerate carry gold but, since the rock as a whole is impregnated with later sulphides and quartz possessing an auriferous content, it is maintained that the rocks of Northern Kavirondo owe their value to at least two different ages of gold-bearing solutions.

"The Petrology of the Kilembe Copper Deposits," by W. C. Simmons and H. F. Harwood, with chemical analyses by the latter, deals mainly with the rocks in the immediate vicinity of the mine. The zone of oxidation of the ore-deposits does not go down below the 60 ft. level and contains malachite, azurite, chrysocolla, cuprite, chalcocite, and tenorite. The sulphide zone contains pyrite and chalcopyrite. In some of the adits a sulphide of cobalt with nickel, occurring in intimate association with the chalcopyrite, has been identified as linnæite. So far as is known at present, the ores are free from arsenic, antimony, zinc, and lead, metals which would

introduce complication in smelting, but contain some cobalt and nickel which might enhance their value.

The article on "Gravity Measurements in East Africa," contributed by Dr. E. C. Bullard of the Department of Geodesy and Geophysics, Cambridge, contains the information, not without bearing on the petroleum-winning possibilities of the Albertine depression, that gravity measurements carried out in the rift valleys during 1933-1934 revealed values markedly less than the theoretical value.

The Bonsa Diamondfield, Gold Coast Colony.—The following note has been kindly contributed by N. R. Junner, O.B.E., M.C., D.Sc., D.I.C., Director of the Geological Survey, Gold Coast.

Diamond was first discovered in the Bonsa River gravels by the Geological Survey in 1922 (Annual Report of the Gold Coast Geological Survey, 1922-23, p. 27). No further development took place until 1929, when other diamonds were discovered by African prospectors in the gravels of the Chirifan and Bediabawu streams close to the Tarkwa-Anibil motor road, some 4 to 8 miles south-west of Tarkwa. As a result of these discoveries further investigations were made by European companies and the country on both sides of the above-mentioned motor road was prospected over a length of some 22 miles from Tarkwa to beyond Simpa. This work proved the existence of a diamantiferous belt about 14 miles long and 1 to 4 miles wide.

Some small deposits much richer than the average were discovered in the Enikawkaw, Ntisini and Nfutu streams, which flow north into the Bonsa and in the Pintotum and tributaries of the Bediabawu, between Akyempim and Aguna, but most of the ground was found to be patchy and poor.

Early in 1933 the Africans began to work deposits on their own account, a venture which has been so profitable that there are now nearly 1,000 Africans engaged in winning diamonds and the monthly output, which fluctuates rather widely, averages about 6,000 carats. On an average the gravel is about 1 ft. thick and the overburden 2 or 3 ft., but the depths vary greatly from place to place. The usual method of working the deposits is similar to that employed by the Africans in winning gold from alluvial deposits. They work in parties of two or three (a man and his wife and sometimes a child) and sink small isolated pits to the gravel, which is washed in wooden calabashes. The men do the digging and the women the washing. Their method of working is simple and rapid, but very wasteful. Approximately one-third of the diamonds in the treated gravel is lost and a large proportion of the gravel remains untreated owing to the

haphazard methods used in selecting sites for pits and to the fact that only the richest sections of the gravels are chosen.

On an average each party recovers about one-third of a carat of diamonds per day. In the Dompim chiefdom all workers (including strangers) give one day's production per week to the chief, who also takes one-tenth of the value of all the stones sold. In the Simpa chiefdom, the chief receives one day's production per week from his own people and two days' production from strangers.

The underlying rock in practically all the workings is the Kawere conglomerate, the basal member of the Tarkwaian System, which in this area is composed largely of pebbles of Upper Birrimian rocks, but a few diamonds also occur in streams draining Upper Birrimian (volcanic and sedimentary) rocks. It seems probable that the diamonds are derived locally from the Kawere conglomerate, but their ultimate origin is probably in the Upper Birrimian igneous and pyroclastic rocks. The staurolite and kyanite associated with the diamonds are certainly pre-Tarkwaian in age.

The gravels consist of a mixture of sub-angular and rounded pebbles of schorl-quartz rock, tourmaline-schist, jasper, hornstone, greenstone and porphyry derived largely from the Kawere conglomerate, with angular quartz from veins in the Tarkwaian and Birrimian rocks.

The principal heavy minerals in the concentrates are staurolite, limonite, schorl, zircon, kyanite, ilmenite, magnetite, rutile and gold. Corundum (including deep blue sapphire) and pleonaste have also been found occasionally.

The diamonds are small and average about forty to the carat. Boart comprises about 40 to 45 per cent. of the total and fine sand under 1 mm. about 25 per cent. Brown stones predominate and green diamonds are relatively common. Average parcels realise about 8*s.* per carat.

Production of diamonds started in May 1933; and to the end of December 1934, 5,000 carats had been produced. No figures are available of the output from January to April 1935, but from May to November 1935 inclusive, 31,517 carats valued at £14,467 were produced. Of this total 9,473 carats valued at £3,932 were won in November 1935.

The Ratnagiri Chromite Deposit, Bombay Presidency.—Attention has recently been directed to the possible exploitation of chromite in the Ratnagiri district, India, and in this connection the following notes, kindly supplied by Dr. P. K. Ghosh, of the Indian Geological Survey, through the courtesy of Dr. A. M. Heron, Director of the Survey, will be of interest.

The deposit occurs in the valley of the Gad river, 1 mile

to the north-north-east of Kanakauli (lat. 16° 16′: long. 73° 45′) in the Devgadhtaluka of the Ratnagiri district and has the aspect of a roughly east-west dyke or a vein intersecting the older country-rocks formed of pre-Cambrian gneisses, phyllites and banded quartz-hæmatite schists, the general schistosity of which strikes NW-SE.

The occurrence is first mentioned in this BULLETIN, 1910, 8, 401. A later reference to the Ratnagiri chromite appears in the Imperial Institute Monograph on *Chromium Ore* (1921), p. 18, as follows: In the Bombay Presidency, 60 miles from Ratnagiri, large outcrops of chromite occur associated with serpentine. Some of these outcrops are stated to be 1,000 ft. long and 300 ft. wide. Specimens assayed about 34 per cent. Cr_2O_3. (See also Director's General Report, *Rec. Geol. Surv. India*, 1934, 68, pt. 1, p. 30.)

The Kanakauli deposit is associated with serpentine, an altered phase of an ultrabasic intrusive magma of which the chromite deposit is a differentiation product. The chromite deposit can be traced in a roughly east-west direction for about half a mile and its width varies between 30 ft. and 6 ft. The serpentine mass is not observed throughout the whole length of the deposit, but appears sporadically along the strike of the lode. One good exposure of the serpentine is met with in the river bed itself where the chromite is found to occur, not at the centre of the serpentine mass, but along its margins. Four pits, each about 7 ft. deep, have been sunk along the strike of the lode by Messrs. Oakley, Duncan & Company, Ltd. (who have acquired a mining lease since last year for ten years in the first instance) and the lode has been struck in each case. The mineral vein seems to be vertical or nearly so.

In hand specimens of the ore the chromite is seen in the form of minute grains associated in varying proportions with a flaky chlorite-like mineral. The refractory properties were tested both on a fragment of the ore and a powdered portion of the same. At a temperature of 1400° C., the marginal angularities of the chipped fragment showed a distinct tendency to be rounded off; the powdered portion became fused into a cake. Another portion of the powder in which the chromite grains were concentrated by panning also fused into a cake at 1400° C. An assay made by Mr. Mahadeo Ram in the Laboratories of the Geological Survey of India yielded 41·58 per cent. Cr_2O_3 and 25·26 per cent FeO. Thus taking the refractory properties into consideration and also the fact that the assays yield between 34 and 41·58 per cent. Cr_2O_3, it seems doubtful whether the deposit will be of economic value in normal times, unless the quality of the ore improves with depth.

The River Irrawaddy Oilfield, Burma.—In 1929, the Geological Survey of India reported that the River Irrawaddy almost certainly flowed over oil deposits of commercial value and that a scheme was to be considered for reaching these by a tunnel large enough to accommodate derricks. Such an ambitious project has had to be abandoned until the world prices of oil justify the expenditure, but of equal interest are the successful efforts which have been made to reach the fringes of the oil zone. These are the river-bed reclamation works which have been carried out by the Indo-Burma Petroleum Company at Lanywa on one side and by the Burma Oil Company at Singu on the other (*Petr. Times*, 1936, **35**, 297-300, 335-336).

The first attempts to prove oil were made in 1913 and a well was sunk on a sand bank in the river bed at Lanywa, it being hoped that the bank would be above water even at the greatest height of the river. These hopes were unfounded and the bank was flooded out before the oil horizon was struck.

After the war period the work was resumed and the method adopted included building a retaining wall behind which the river bed could be filled up and which would be able to withstand a 35 ft. rise in the river level. Advantage was taken of a sand bank on which to build and align the wall and it was raised by means of a bucket dredger to a height of 42 ft. above low-water level. The dimensions are 150 ft. wide at the base and 15 ft. across at the crown. The outer slope was protected from flood scour by a coating of clay 2 ft. thick, over the sandy matrix and a facing of dressed stones. Undercutting of the sand bank was checked by a stone apron 100 ft. wide stretching from the toe of the retaining wall to the edge of the bank.

Work began in the low-water season of 1925-26 and was completed three seasons later, to a length of 5,600 ft. at a cost of Rs. 2,000,000 (£150,000). During the second low-water season a test well was drilled behind the wall, but this failed to reach its object and it was not until 1928 that oil sand was first struck and the Lanywa field proved. In 1930, it was decided to extend the embankment a further 3,300 ft. So much local stone had been used in the original work, however, that the quantity available was inadequate and transport costs from other sources were prohibitive. The difficulty was overcome by manufacturing bricks on the spot, each measuring 12 in. × 12 in. × 6 in. and weighing 65 lb. and in the first year 67,000 were produced. In addition it was discovered that the sand bank deviated from the line of the extension almost immediately beyond the old embankment and this necessitated an artificial bank being raised.

In two years the work was completed and proving so successful that yet another extension was undertaken and completed last year, bringing the total length of wall to 10,300 ft. The construction scheme consumed 2,122,000 tons of material as follows: Sand, 1,627,000 tons; stone, 303,000 tons; clay, 112,000 tons; brick, 80,000 tons.

For the first three years of the construction period the field behind the wall was a sand flat at the low-water season, but at other times formed a lake some 25 to 30 ft. deep. Means had to be adopted to permit of a continuous drilling programme being carried out. The method adapted was to erect the rigs on concrete foundations sufficiently massive to withstand the drilling stresses and connect these to the shore by steel foot-bridges. When sufficient information had been obtained as to the extent of the oil field the in-shore area was filled up and by the end of March 1935 an artificial peninsula 2 miles long and ¼ mile broad and permanently above high-water level had been constructed and now has over 75 oil wells. In 1933, the production was 19,257,024 gals. and in 1934 there was an increase of about 2½ million gals.

To protect the machinery from drift sand in the S.W. monsoon, 75 acres of Marram grass and over 1,300 trees were planted.

The Burmah Oil Company is now repeating the work on the Singu side of the river. The retaining wall is to be 5,000 ft. in length and at present 3,000 ft. and a considerable amount of infilling have been completed. The wall is of heavy sand and gravel, raised directly from the river bed to a height of 43 ft. above low-water level and 3 ft. above the maximum rise. All the materials for reclamation are of local origin and special bricks have been made for part of the outer facing, the rest being of stones.

On the top of the embankment a level way is arranged, 15 ft. wide, to take a light railway, electric lighting posts, etc , for construction purposes. Most of the work is done by a wharping dredger capable of delivering from two suction pumps 9,000 to 30,000 cu. ft. of sand per hour and a drag-line excavator with an output of 4,000 to 4,500 cu. ft. an hour, used mainly for constructing the embankment.

Coal Deposits of Tete, Mozambique.—In Central and Eastern Africa there has been a growing demand for coal to replace the timber which is being cut at an alarming rate; and the coal area around Tete, an important station in the west of Mozambique, seems likely to meet this need.

The area, which is traversed by the River Zambesi, is on a plateau 4,000 ft. above sea-level and covers approximately 65,000 sq. miles (*Afr. World.* *Central, West, East Africa*

No., 1936, p. 124). The river is navigable, in the season from December to July, from the mouth (Chinde) for a distance of 390 miles to the Onebrabassa Falls above Tete. Livingstone described the district as a vast coalfield surrounded by a belt of iron ore and since that time gold, copper, graphite and mica have been located.

In 1919, Zambesi Mining Development, Ltd., carried out a survey, the results of which led to the formation of a company to explore the possibilities of working the coal deposits. As a result of geological work, some 100 million tons of readily-accessible coal were proved in the Tete basin, in addition to reserves in other localities. In 1922, a mine was opened at Moatize, 14 miles from the river and by 1933 a narrow-gauge railway had been constructed to Benga, from which the coal is shipped by barges to its destinations.

The seams, which average 12 ft. in thickness under about 200 ft. of cover, are worked from a vertical shaft by the pillar and stall method and the coal reaches the surface in 10 cwt. tubs, where it is screened to two sizes. A briquetting plant utilises the small coal. The efficiency of the native labour is high and the pit-head price of the coal compares favourably with that of South African and Rhodesian coals. Of the prospective output for this year (1936) sales amounting to 10,500 tons have been booked.

The following are analyses of two samples of the coal made in 1930 :—

	(1) Per cent.	(2) Per cent.
Fixed carbon	61·55	55·58
Volatiles and organic matter	19·30	18·27
Ash	18·27	25·44
Sulphur	0·92	1·22
Moisture at 100° C.	0·88	0·71
Evaporative power	12·32	11·56
Calorific value, calories	6617	6209

All the coal produced can be coked for metallurgical purposes. For the full development of this field a railway will be necessary, crossing the Zambesi and connecting with the Nyasaland-Beira systems, when an extensive bunker market at Beira could no doubt be fostered.

Use of Magnetite in the Manufacture of Heavy Concrete.— In the construction of the concrete counterweight of the double-leaf bascule bridge recently built between Oakland and Alameda, Calif., U.S.A., a heavy aggregate of steel punchings or other approved material was specified.

Steel punchings are difficult to obtain in large quantity and costly to clean, a uniform mixture is not easily prepared and corrosion of the steel may cause spalling of the concrete. R. B. Rothschild, Jr., of the company which constructed the

bridge, experimented with heavy aggregates and as a result magnetite sand was found to be suitable and was finally used. (*Engng. News Record*, 1935, **115**, 788-9.)

In contrast to steel stampings this material is easy to obtain and non-corrodible. Magnetite sand from a convenient beach deposit near Aptos, Calif., where natural concentration had occurred, was employed, and the material was further concentrated by an agitator-drum magnetic separator. The product obtained was very fine, only a small proportion being retained on a No. 50 sieve, and about 17 per cent. passing a No. 100 sieve. The proportions of the mix per cubic yard, selected as a result of extensive tests, were as follows :—cement 752 lb., magnetite 2,700 lb., gravel 1,150 lb., water 48 gals. The gravel was suitably graded and contained material from $\frac{3}{8}$ in. size down to No. 50 sieve. Gravels containing finer or coarser material were not satisfactory. The concrete weighed 182 lb. per cubic foot and compressive strengths as high as 4,800 lb. per sq. in. in 28 days were obtained, a decided tendency to late strength being apparent. The surface of the concrete was uniform, smooth and very hard. It is suggested that the addition of magnetite would be useful in the construction of concrete floors or pavements subject to heavy abrasion.

Possible Uses for Spent Fuller's Earth.—Oil refiners using fuller's earth for decolorisation purposes have long been faced with the problem of the economical disposal of the spent material.

Actual and possible new uses for this waste product are described in an article by H. L. Kauffman (*Nat. Pet. News*, 1935, **27**, No. 52, p. 25 and 1936, **28**, No. 1, p. 21).

It is claimed that the material can, with advantage, replace all or part of the sand commonly employed in the preparation of gypsum mortars, and that such mortar mixtures can be applied more easily, more rapidly and with much less loss in handling than the more conventional plaster and sand mixtures. Also the covering capacity of the spent earth mixture is greater for the same weight of raw materials.

The setting time of the mixture commonly used is about 46 minutes when using spent fuller's earth as against 16 hours for a sand mixture. The tensile strength of the mortar made with spent earth is somewhat lower than that of a similar sand mixture, but a certain amount of this relative weakness is offset by the lower specific gravity of the spent earth mixture.

Spent fuller's earth contains a small percentage of absorbed hydrocarbons which render plaster compositions made from it practically waterproof, and weathering tests on such mortars showed that very little disintegration took place over a period of six months.

The relatively high porosity and low specific gravity of the spent earth account for the appreciable sound-absorbing properties of mortars made from it, but it is not claimed that such mortars can be described as true "acoustic plasters." For the same reasons spent earth mortars are of value as insulating media. A further advantage of spent fuller's earth in this connection is that a mortar can be dry mixed and stored for periods up to six months without showing any appreciable signs of hardening, while mixtures of sand and plaster rapidly absorb water and harden.

The particle size of spent fuller's earth for use in plaster compositions should conform to A.S.T.M. specification for gypsum plaster (*A.S.T.M. Stand.*, 1930, Pt. II, p. 105). Such material, when new, is known to petroleum refiners as 30-60 mesh.

When properly conditioned and used in the correct proportions the spent earth may also be employed to replace part of the sand in portland cement-sand mixtures. Its substitution for the whole of the sand does not appear to be practicable on account of the decrease in strength entailed. Fine concrete made from a mixture containing spent fuller's earth is substantially waterproof, and this property, coupled with its low specific gravity, should make it a suitable material for the manufacture of concrete building blocks. Detailed information regarding its use in concrete is, however, not available on account of pending patents.

The use of ignited spent fuller's earth as a decoloriser and deodoriser for industrial water purification has, according to authorities quoted, advantages such as neutralisation of acid bodies contained in the water, reduction of suspended matter, etc. When ignited spent earth is added to the raw water during and immediately after the addition of the alum commonly employed for the coagulation of the suspended matter, the formation and rate of settling of the alumina floc is greatly accelerated.

Properly conditioned spent fuller's earth has definite advantages over crushed limestone and similar materials as a constituent of asphaltic paving compositions, and its substitution for such materials results in increased hardness over an extended temperature range.

The product resulting from the distillation of coal in the presence of fuller's earth is satisfactory for use as a carrier for catalytic agents and also as a high quality black pigment for paint manufacture.

Finely-ground spent fuller's earth also has possibilities for use in cheap paints, and when mixed with arsenic compounds, sulphur, etc., effective insecticides and fungicides may be produced.

RECENT RESEARCH ON EMPIRE PRODUCTS

A Record of Work conducted by Government Technical Departments Overseas

AGRICULTURE

Manures

Nigeria.—The following account of green-manuring experiments at Umuahia is taken from the half-yearly report of the Chemical Section, Southern Provinces, for July-December 1935, prepared by H. C. Doyne and W. A. Watson:

Owing to the fact that heavy dressings of lime produced a depressing effect on the green manure cover-crop (*Calopogonium mucunoides*), various pot experiments were undertaken to ascertain the effect, if any, of finely-ground local rock phosphate on these very acid soils. It was found that, while rock phosphate had little or no direct effect on the test crop (a small growing millet from the Northern Provinces), where a green manure crop was grown first and dug in the effect was very striking; the weight of millet being twice that from the pots receiving green manure alone and six times that from the untreated pots. Chemical analysis of the soil from the pots after the experiment showed a very slight increase in *p*H value and base saturation and a large increase in available phosphorus for the rock phosphate treated over the untreated soil.

Mr. W. A. Watson also reports that a small scale field experiment was carried out during the year in the light of previous experience of farmyard manure *versus* artificials. It had been found that farmyard manure was much increased in value by the addition of its equivalent of phosphate and potash, but that additional nitrogen showed no notable increase.

It was decided to try every combination of the three artificials with and without farmyard manure. This involved sixteen treatments:—

<table>
<tr><td>1.</td><td>O</td><td>No artificials.</td><td rowspan="8">in quantities equivalent to 2 tons f.y.m.</td><td rowspan="8">with and without farmyard manures.</td></tr>
<tr><td>2.</td><td>N</td><td>Nitrate of soda.</td></tr>
<tr><td>3.</td><td>P</td><td>Superphosphate.</td></tr>
<tr><td>4.</td><td>K</td><td>Muriate of potash.</td></tr>
<tr><td>5.</td><td>NP</td><td></td></tr>
<tr><td>6.</td><td>PK</td><td></td></tr>
<tr><td>7.</td><td>NK</td><td></td></tr>
<tr><td>8.</td><td>NPK</td><td></td></tr>
</table>

Guinea corn was sown after the rains had started. All the manure had been added a few days previously, except the

nitrate, which was applied a few days after sowing in the wet soil.

From an early stage there were striking differences in growth.

(*a*) It was clear that the plots receiving farmyard manure were doing better than those without.

(*b*) It appeared that phosphate-treated plots were showing an immensely better response than those treated with K or N.

(*c*) Nitrogen appeared to have no beneficial effect—in fact, later in the season N alone seemed to be having an adverse effect.

(*d*) Potash showed no improvement.

Yield results are shown below :—

Treatment.	Actual yield of grain in lb. No f.y.m.	Actual yield of grain in lb. With f.y.m.	Actual yield of leaves and stems in lb. No f.y.m.	Actual yield of leaves and stems in lb. With f.y.m.
O	74	136	138	274
N	70	131	138	268
K	88	129	156	279
NK	65	128	132	275
P	148	196	288	404
PK	132	191	271	397
NPK	154	209	329	471
Total	881	1323	1790	2842
Standard error to compare no f.y.m. and f.y.m.	±9 units, hence 27 units is a significant difference.		±17 lb., hence 51 lb. is a significant difference.	
Standard error to compare sub-treatments.	±7 units, hence 21 units is a significant difference.		±14 lb., hence 42 lb. is a significant difference.	

So far as grain yields are concerned the effects of the artificials fall into two groups, whether with or without farmyard manure :—

(*a*) N, K and NK—no effect.

(*b*) P, PK, NP and NPK—an increase of 60 or 70 units.

The yields for leaf and stem follow the same order, with the exception that N in conjunction with P has a considerably greater effect.

These results are in line with those of the past two years. Using superphosphate as the source of phosphate, better results have been obtained from complete artificials than from farmyard manure containing the same amount of nutrients. Previously ground rock phosphate had been used and there was no response to its use.

It would now appear that phosphate alone counts for grain yield, while nitrogen increases the vegetative growth.

BEVERAGES

Coffee

Uganda.—The following account of pruning experiments on Arabica and Robusta coffee is contained in the report of the Kampala Experiment Station for July-December 1935.

1. *Arabica Coffee Pruning Experiment* (Plot No. 3).—This experiment was commenced in 1927 and is a trial of three methods of pruning—Single Stem, Agobiada and Multiple Stem. The plot was planted with Arabica coffee (Nyasaland variety) in 1924 at a spacing of 10 ft. × 10 ft. and is shaded by rain trees (*Pithecolobium Saman*) spaced at 40 ft. × 40 ft. The area is approximately one acre and it has been divided into 20 sub-plots—seven under Single Stem pruning, seven under Agobiada pruning and six under Multiple Stem pruning; the results are expressed as pounds of fresh cherry per sub-plot. The yields to date have been as follows:

Yields per Sub-plot (lb.)

Method of Pruning.	1927–34.	1935.	Total
Single Stem (A)	484·4	45·4	529·8
Agobiada (B)	747·6	78·4	826·0
Multiple Stem (C) . . .	663·7	14·5	678·2

There are a certain number of blank spaces in the plot and the total number of trees in the heaviest yielding plots, those pruned by the Agobiada system, is 127: if the yield is calculated on the basis of the actual number of trees present, for the nine years 1927-35, these plots have yielded at an average rate of about 2,200 lb. of fresh cherry, which would correspond to about 4 cwts. of dried coffee per acre per annum.

The plots under other treatments have given smaller yields, but it is obvious that, with these methods of pruning, a spacing of 10 ft. × 10 ft. is too wide, especially in the case of the bushes pruned on the Single Stem system and it is probable that higher yields would have been obtained by closer planting.

2. *Robusta Coffee Pruning Experiment* (Plot No. 4).—The object of this experiment is to compare the yields obtained from Robusta coffee when it is subjected to the following methods of pruning:—

1. Single Stem.
2. Agobiada.
3. Costa Rica Multiple Stem.
4. Modified Costa Rica Multiple Stem.
5. Tree or open Multiple Stem.
6. Kinawa or Upright Stem.

The plot is nearly one acre in size; in 1930 it was planted with progeny rows from various selections of Robusta coffee, at a spacing of 8 ft. × 8 ft. The various methods of pruning were commenced in 1931 and are laid down in lines across the progeny rows; there are four replications of each treatment but they are not randomised; individual tree records have been kept.

The coffee commenced to fruit in 1932 and the results to date have been :—

Average Yields of Fresh Coffee (in oz.) per Tree

Year.	1 Single Stem.	2 Agobiada.	3 Costa Rica Multiple Stem.	4 Modified Costa Rica Multiple Stem.	5 Tree or open Multiple Stem.	6 Kinawa or Upright Stem.	Total.
1932	21	3	9	7	6	2	48
1933	154	169	133	120	145	145	866
1934	212	284	243	225	252	246	1462
1935	111	234	212	193	183	205	1138
Total	498	690	597	545	586	598	3514

As the layout was not randomised, it is not possible to analyse these figures statistically; but it may be noticed that while the Single Stem method of pruning caused the production of slightly larger crops at first than did the other methods, it now seems to produce definitely smaller crops, while the Agobiada method produced yields heavier than did the other treatments. The yield of this plot as a whole has been quite satisfactory; for example, the bushes under the Agobiada treatment within five years from planting have yielded at a rate of 29,300 lb. of fresh cherry per acre; as the average ratio for this plot of dry beans/fresh coffee is 22 per cent., this corresponds to 6,450 lb. of dry coffee = approximately 57 cwts.; in 1934 the yield of these bushes was at a rate of about 12,050 lb. per acre of fresh cherry = approximately 26½ cwts. of dry bean; in 1935 the figures were 9,950 lb. fresh cherry = approximately 19½ cwts. of dry bean per acre. These high figures, in part, may be explained by the close spacing of the coffee and it is probable that the yield will fall off, for some of the trees, especially those pruned on the Multiple Stem Systems and the "Kinawa" System have not room for their development.

Oil Seeds

Chaulmoogra

Uganda.—According to the half-yearly report on the Botanic Gardens, Entebbe, for July-December 1935, the

good growth of *Hydnocarpus Wightiana* and *H. anthelmintica* remarked upon previously has been maintained on the whole. Four additional trees of *H. Wightiana* and eight of *H. anthelmintica*, have come into bearing since June. These have brought the total of each species in bearing to sixteen and seventeen respectively, figures representing slightly below 50 per cent. of the trees which make up the plots. It is now presumed that most of the remaining trees will turn out to be male trees as very few are left undetermined.

An analysis of the data collected so far shows the former species to have been the more prolific, an average of 99·9 fruits per tree has been produced compared with only 17·9 in the case of *H. anthelmintica*.

A reverse result was noted, however, when taking the number of seeds per fruit into account, *H. anthelmintica* had an average of 35·6, while that per fruit from *H. Wightiana* was as low as 9·6.

Ground-nuts

Nigeria.—Mr. J. K. Mayo, in the report of the Botanical Section, Northern Provinces, for the period July-December 1935, states that the improved upright variety Castle Cary continues to show increased yields over the local mixture at Kano and other northern stations, but has failed to show any improvement over the local mixture at Zaria for the past seasons, an unexpected result since this strain was selected at Zaria.

The results of such of the 1935 yield trials as have been worked out are :—

Zaria (all upright varieties)

		Yield as per cent. of control.	Shelling percentage.
Control (local mixture)	647 lb. kernels per acre	100	70·7
C.C.	633 ,, ,, ,, ,,	98	72·6
S.	693 ,, ,, ,, ,,	107	72·3
T.	711 ,, ,, ,, ,,	110	72·9

There was no significance.

Kano

		Yield as per cent. of control.	Shelling percentage.
Control (Danberta seed)	989 lb. kernels per acre	100	71·9
C.C.	1154 ,, ,, ,, ,,	117	72·1
D.S.	1077 ,, ,, ,, ,,	109	70·7
K23	974 ,, ,, ,, ,,	98	70·9

All except C.C. are spreading varieties.

Layout.—$\frac{1}{8}$-acre plots. 8 randomised blocks. No significance.

A smaller scale trial on $\frac{1}{55}$-acre plots with 10 randomised blocks gave :—

		Yield as per cent. of control.
Control (Danberta seed)	461 lb. kernels per acre	100
Strain 8	642 ,, ,, ,, ,,	139
,, C.C.	603 ,, ,, ,, ,,	131
,, 10	562 ,, ,, ,, ,,	122
,, 12	547 ,, ,, ,, ,,	119
,, 9	521 ,, ,, ,, ,,	113

8 was significantly better than Control and 9.
C.C. ,, ,, ,, ,, Control.
10 ,, ,, ,, ,, Control.

Uganda.—The report submitted by the Director of Agriculture on the work carried out at the Serere Experiment Station during the half-year July-December 1935, contains the following account of a ground-nut variety, weeding and mulching trial.

This experiment was designed for a comparison of the normal farm method of clean weeding of ground-nuts with the following treatments :—

(*a*) No weeding for the first month followed by clean weeding.

(*b*) No weeding at all.

(*c*) Mulching with grass.

The local varieties of the spreading and bunch type of ground-nuts were used and the layout was five blocks of the two varieties subdivided for treatments.

The results obtained showed that :—

(1) The local spreading variety was a significantly superior yielder to the local bunch variety.

(2) Mulching with grass gave a significant increase in yield over all other treatments while "clean weeding" and "no weeding for a month" gave a significant increase in yield over "no weeding at all."

(3) The interactions between varieties and treatments were significant because with the spreading variety there was no significant reduction in yield through "clean weeding" or "no weeding for a month" when compared with mulching, while with the bunch variety both "clean weeding" and "no weeding for a month" have depressed the yield.

At the Bukalasa Station a variety trial with five varieties gave the following yields :—

	lb. per acre unshelled.
Bukalasa Bunch	2,783
Virginia Bunch (Bukalasa)	2,765
African Bunch	2,003
Philippine Pink	1,913
Virginia Bunch (Serere)	1,849
Least Significant Difference	290

In the Spacing Trial at the same Station close spacing again showed considerable superiority over wide spacing. The results were as follows :—

Spacing.	Seed Rate (unshelled).	Yield per acre unshelled. *lb.*
½′×½′	234	3,055
1′×½′	110	3,144
1′×1′	61	2,414
2′×1′	32	1,603
Least Significant Difference		757

Thus all the closer spacings are better than 2′ × 1′ spacing.

Sugar

Cane

Windward Islands. *Antigua.*—An interesting account of experiments with sugar cane is contained in a report on investigational work conducted in Antigua during July-December 1935, but it is regretted that owing to exigencies of space its publication must be deferred until the next issue.

Root Crops

Sweet Potatoes

Leeward Islands. *Antigua.*—The following statement is contained in the report on investigational work conducted in Antigua during the period July-December 1935.

The variety trial planted in June 1934 was reaped in February 1935. The lay-out was a six by six Latin square, the individual plots being each $\frac{1}{80}$ acre in area. At the time of reaping it was observed that the plots of White Gilkes were not pure but were contaminated with Red Nut and the yield from these plots is returned as " mixed." The following table shows the mean yields :—

Variety.	Yield per acre. *tons.*
V.52	7·95
Brookes Seedling	7·50
Moore	6·68
Red Nut	6·27
Mixed (White Gilkes and Red Nut)	6·27
Bert	4·62

Differences will not exceed 0·31 ton per acre more often than once in 100 times. V.52 is significantly better than any other variety.

V.52 has headed the list for two years in succession and on both occasions Bert has given the lowest yield.

The same six varieties have again been planted in varietal trial, this time in October, to determine their suitability for cultivation during the cooler months.

TOBACCO

Mauritius.—The Imperial Institute has been furnished with the following statement on tobacco production in Mauritius during the season 1934-35, prepared by Mr. Geoffrey Corbett, Government Tobacco Officer.

Production.—During the year under review the Tobacco Board issued 308 certificates for the cultivation of 404 acres of tobacco, as compared with 327 certificates for the cultivation of 1,080½ acres in the preceding year. This reduction in acreage was rendered necessary on account of the large stocks of leaf on hand at the end of 1934 and was effected in order to enable stocks to be partly liquidated. In addition to this, purchase prices were reduced by 25 per cent. The crop was limited to 200,000 kilos., of 500 kilos. per acre, any surplus to be destroyed. During the delivery of the crop each planter was paid up to his quota of 500 kilos. per acre and any surplus delivered by planters, over their quota, was placed in a surplus pool and not paid for. At the end of the crop a sufficient quantity of leaf was taken from the pool to bring the crop up to the requisite quota of 200,000 kilos. and the planters concerned were paid for leaf so taken. Of the total acreage registered, i.e. 404 acres, 394½ acres only were cultivated as is shown in the following table.

TABLE I

Area Cultivated

Type.	1934-35. *acres.*	1935-36. *acres.*	Decrease. *Per cent.*
Flue-cured .	676	286½	57·6
Air-cured .	245	108	55·9
Total .	921	394½	57·1

Crop Conditions.—Generally, conditions were favourable for tobacco, but in the early part of the year "damping off" disease (*Pythium* sp.) caused considerable damage in seed beds. The warm, moist conditions prevalent were also conducive to the spread of disease which caused considerable damage in certain plantations, the chief diseases being "Black Shank" (*Phytophthora* sp.) and "Granville Wilt" (*Bacterium solanacearum* E.F.Sm.). Heavy winds encountered during July

caused much damage to the early plantations and were responsible for a large amount of the damaged leaf delivered at the warehouse. Abundant, late rains, which occurred during October, caused secondary growth and, whilst yields were increased, the quality suffered.

Crop Returns.—The yields and values of the leaf produced and the amounts of the various grades are dealt with below.

TABLE 2

Acreage Yields

Type.	1934-35.			1935-36.			Variation in Yield per acre.
	Acres.	Yield in Kilos.	Kilos. per acre.	Acres.	Yield in Kilos.	Kilos. per acre.	*Per cent.*
Flue-cured .	676	302,377·9	447·3	286½	141,728·6	494·6	+10·5
Air-cured .	245	142,720·6	582·5	108	59,516·9	551	− 5·4
Total .	921	445,098·5	483·2	394½	201,245·5	510·1	+ 5·5

The highest yield recorded for flue curing was 979·2 kilos per acre and the lowest was 159·2 kilos. per acre; for air curing, the highest was 1,292·5 kilos. per acre and the lowest was 73 kilos. per acre.

TABLE 3

Acreage Values

Type.	1934-35.	1935-36.	Decrease. *Per cent.*
Flue-cured .	Rs. 601:69	Rs. 523:78	12·9
Air-cured .	Rs. 490:15	Rs. 462:03	5·7

The variation in acreage value was as follows: flue curing, highest recorded: Rs. 1,103:42 per acre; lowest: Rs. 175:63 per acre. Air curing, highest recorded: Rs. 574:99 per acre; lowest: Rs. 58:26 per acre.

TABLE 4

Average Value of Leaf per Kilo.

Type.	1934-35.	1935-36.	Decrease. *Per cent.*
Flue-cured .	Rs. 1:34	Rs. 1:05	21·6
Air-cured .	Rs. 0:84	Rs. 0:83·8	0·2

During the year under review the average value per kilo. and the acreage values were affected by the reduction of 25 per cent. in purchase prices.

The variation in the average value per kilo., for the different estates, was the following: For flue curing, highest recorded: Rs. 1:69·4 per kilo.; lowest recorded: Rs. 0:80·5 per kilo. For air curing, highest recorded: Rs. 1:22·9 per kilo.; lowest: Rs. 0:45·2 per kilo.

TABLE 5

Grades of Flue-cured Leaf Produced

Grades.	1934-35. Kilos.	Per cent.	1935-36. Kilos.	Per cent.
Bright .	9,671·1	3·10	6,881·7	4·86
Medium	103,679·8	34·28	67,589·6	47·76
Dark .	145,882·3	48·34	45,944·2	32·42
Perished	25,233·6	8·35	13,307·0	9·33
Green .	8,635·5	2·86	4,508·4	3·17
Scrap .	9,275·6	3·07	3,497·7	2·46
Total .	302,377·9	100·00	141,728·6	100·00

TABLE 6

Grades of Air-cured Leaf Produced

Grades.	1934-35. Kilos.	Per cent.	1935-36. Kilos.	Per cent.
Bright .	7·0	0·05	65·2	0·10
Medium	10,948·5	7·65	19,160·8	32·19
Red .	99,163·6	69·48	35,921·6	60·36
Dark .	13,863·0	9·71	1,005·0	1·69
Green .	3,324·4	2·31	802·9	1·35
Scrap .	15,414·1	10·80	2,561·4	4·31
Total .	142,720·6	100·00	59,516·9	100·00

The leaf which was forwarded to England during 1935 and which was reported to be satisfactory in every respect, with the exception of flavour, was returned to Mauritius during the year under review as being unsaleable owing to flavour. In view of these unfavourable reports experiments were commenced with other varieties in an endeavour to obtain a variety, or varieties, with a more acceptable flavour and, later, samples of such leaf will be forwarded to London for opinion.

MINERAL RESOURCES

GOLD COAST

The Imperial Institute has received the following statement from the Director of the Geological Survey regarding the work carried out during the half-year ended June 30, 1936.

Four parties were in the field during this period, their work including :—

(*a*) The geological mapping and prospecting, on a broad scale, of Togoland under British mandate.

(*b*) A comprehensive survey of the water supplies of the Northern Territories.

(*c*) A detailed study of the stratigraphy and structure of the rocks of the Tarkwa Goldfield and the adjoining country to the west and south.

(*d*) The workings of most of the active gold mines and prospects were examined.
(*e*) Geophysical Investigations.

Togoland.—The geological work in Togoland was concerned mainly with studying and mapping the rocks of the Oti, Buem and Togo series.

Small deposits of chromite are associated with ultrabasic intrusions in the Togo Series, but they are not of commercial importance.

Hæmatite replaces shale and tillite of the Buem Series, but owing to its distance from the coast and its high silica content, it is not of commercial importance.

The Buem conglomerate contains a little gold and there is also gold in the gravels of the Volta River and small streams flowing over the conglomerate. No concentrations of importance were seen.

An interesting concentration of black platy rutile, associated with black sand and zircon was found in the Klemu and Bluvie, two streams draining off Togo schists near Matsi in the Ho district.

Northern Territories Water Supply Investigation.—For the purposes of this report it was thought advisable to tour every district in order that the recommendations would be more uniform. Naturally enough, less time was devoted to the better known areas than to the lesser known ones.

The report is to serve the purpose of enabling the Gold Coast Government to prepare and consider a scheme for the uniform improvement of conditions over the whole area.

The method adopted consisted in investigating the geology and existing supplies of over 300 towns spaced more or less evenly over the whole area, requirements being assessed on the population figure as given by the 1931 census, 5 gallons per person per day being the supply aimed at. The total requirements for each district were then estimated from that of the towns examined in the ratio of the total population to that of the towns visited.

Rainfall records showed that a total rainfall of 24 in. per annum would be a fair figure to take for the whole of the Northern Territories. It falls in a well-defined rainy season between April and October. Evaporation from surface water is probably about 60 in. per annum.

The density of the population varies between 2 per square mile in Western Gonja to 170 per square mile in the Zuaragu District, averaging 24 for the whole of the Northern Territories and 15 for Togoland. It will thus be seen that the percentage of the total rainfall to be conserved varied from 0·001 per cent. to 0·085 per cent.

The western and northern districts lie mainly on granites,

granodiorite and more basic rocks and gneisses with strong belts of Birrimian phyllite, schists and greenstones and granite roof-pendants derived from them. Fortunately the relief is very low and the rocks are deeply decayed and in places strongly jointed.

Wells in this type of country should show a large measure of success if located with care. The yields are estimated at from 1,000 to 3,000 gallons per day, which quantities have been exceeded in existing wells. Those in the more acid granitic types of rock give the higher yields on account of the greater percentage of quartz sand formed on weathering. Wells in jointed greenstones give a good yield whilst the phyllites form a good impervious bottom for natural pools and artificial reservoirs.

The central and eastern districts lie mainly on sandstones, mudstones and shales of the Voltaian System and, in Togoland, of the Oti River Series. The shale forms mostly low ground and underlies some very large river flats and swamps. It is generally overlain by a cap of lateritic surface ironstone. The run-off is very high in these areas and they dry early. Wells in the shales give only a very low yield. Being impervious, the shale valleys, where not too wide and shallow, offer good possibilities for storing water by means of dams. Tamale, the capital, has such a reservoir. In many places there are large numbers of old storage wells, known locally as *biliga*, dug over a century ago, the art being a lost one. These are flask-shaped wells, with a narrow neck about 18 in. to 30 in. in diameter through the surface ironstone cap leading to a large cavern in the underlying decaying shales. They are generally made in hollows, where they collect and store some 5,000 to 10,000 gallons of water apiece. Occasionally one finds a group of them connected underground.

The sandstone occurs mainly on hill tops and forms both large and small escarpments. Where of sufficient thickness, it stores some water and gives it up slowly in springs and permanent streams. Wells in sandstone are generally satisfactory, but, unfortunately, only in a small area—mainly near the main Gambaga Scarp—is this rock of sufficient thickness to hold much water.

There are several large permanent streams in the country which with their feeders form good reserve supplies. Unfortunately at present there is a lot of tsetse along them, which prevents settlement near the banks.

The total number of new wells required was estimated at 1791 and dams at 26 for the Gold Coast, a preliminary estimate for the mandated area of Togoland being 376 wells and 2 dams, making a total of 2,167 wells and 28 dams.

Tin.—Recently, the alluvial deposits of cassiterite in and near the Mankwadi Lagoon have been worked in a small way.

Geophysical Investigations. Magnetic.—Observations on the diurnal variation were made and indicate minima and maxima at about 10 a.m. and 3 p.m. The former generally lag behind the aneroid minima readings (in feet) by about an hour. The diurnal variation varied between 40 and 100 gamma, averaging 60 gamma. Traverses with a Vertical Force Variometer were made in the vicinity of Lake Bosumtwi, but only weak anomalies were observed. Traverses across the Prestea and Ayeim (Obuasi) reef channels gave no well-defined anomalies.

Electrical.—Resistivity methods were used to advantage in the water supply investigations described previously. They were found very useful for determining the depths and nature of underlying rocks, depths to water table (top) and bottom of water-bearing strata.

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NOTICES OF RECENT LITERATURE

Books for review should be addressed to "The Editor," Bulletin of the Imperial Institute, South Kensington, London, S.W.7.

THE UNION OF SOUTH AFRICA. By the late Professor L. C. A. Knowles, M.A., LL.M., Litt.D., and C. M. Knowles, LL.B. Pp. vii + 356, $8\frac{1}{2} \times 5\frac{1}{2}$. (London: George Routledge & Sons, Ltd., 1936.) Price 10*s*. 6*d*.

This work, issued as Volume III of a series on "The Economic Development of the British Overseas Empire," may be described as a concise historical and economic treatise on South Africa. It is excellently planned and full of illuminating information on questions which in many quarters are imperfectly understood.

The development of the country is shown as starting from the original occupation of the Cape by the Dutch East India Company as a place of call for their vessels and the interesting speculation is raised as to "how and when the Cape would have become a white man's settlement had the Suez Canal been available in the middle of the seventeenth century." For South Africa differs fundamentally from Canada and Australia in its mode of development. In Canada, for example, "geographical expansion took the form of penetration inland from a number of different points

that were far apart" ; but in South Africa there was for a long period little or no genuine colonisation and in fact the Dutch East India Company definitely discouraged the movement of population outwards from the original settlement. It is not always realised that—again in contrast to the two other Dominions mentioned—the Union of South Africa even to-day has a white population of under two million (i.e. less than that of Wales) whilst the figure for the native races is three times as large. The resulting social, economic and political problems are further complicated by circumstances such as the presence of a considerable Indian population in Natal and the existence of the class known as " poor whites."

The following titles of some of the chapters may be quoted to illustrate the scope of the work :—The Farming Industry in the Primitive and Pastoral Stage: Development of Commercial Farming and Growth of the Agricultural Side: The Fight against Drought, Plagues and Pests: The Movement Towards Rationalization in the Mining Industries: The Labour Problem in the Mines: The Position of the Native in the Economic Life of the Dominion. A classified bibliography is furnished and numerous references to previous publications are given in footnotes throughout the volume. The book can be strongly recommended to readers interested in the history of the Union or in the various difficult problems which confront its administrators.

JAN VAN RIEBEECK. A BIOGRAPHICAL STUDY. By C. Louis Leipoldt, Hon.D.Lit. Pp. xiv + 292, $8\frac{1}{2} \times 5\frac{1}{2}$. (London, New York, Toronto: Longmans, Green & Co., Ltd., 1936.) Price 12*s*. 6*d*.

In the Preface to this volume the author calls attention to the fact that there has hitherto existed no Life in English of Jan van Riebeeck, the Founder and first Governor of the Cape. He also states that in writing the book his main difficulty was to compress within suitable limits a mass of material of historical and cultural interest. He has, however, succeeded in furnishing an extremely readable and illuminating story of van Riebeeck's career and in particular the early years of the Dutch East India Company's administration at the Cape of Good Hope—which, in effect, laid the foundations of the Union of South Africa as it exists to-day. The author has obtained his material largely from the Cape archives, including van Riebeeck's own *Journal* (or *Log-book*), which covers the period (1651-1662) of his actual service at the Cape. The book will appeal to those interested in biographical history and should find many appreciative readers, not only in the Union itself but over a wider field.

THE SOCIAL SYSTEM OF THE ZULUS. By Eileen Jensen Krige, M.A. Pp. xix + 420, $8\frac{3}{4} \times 5\frac{3}{4}$. (London, New York and Toronto: Longmans, Green & Co., Ltd., 1936.) Price 25*s*.

The author of this very interesting volume states in her Preface that the work "is a compilation rather than the result of personal investigations in the field and is intended primarily as a collection and scientific co-ordination of the information scattered about, or lying concealed in, numerous publications." She adds that although the published facts have been amplified by correspondence and also some personal enquiry, the basis of the work remains the writings of others. The wide field from which the contents have been drawn has enabled the author to offer a very full account of her subject. Despite the admitted difficulty of obtaining accurate and consistent details regarding many of the matters dealt with, the volume furnishes an excellent presentation of Zulu customs and traditions and the complicated codes of observances under which tribal life is carried on.

CANADA AND THE BRITISH ARMY, 1846-1871. A STUDY IN THE PRACTICE OF RESPONSIBLE GOVERNMENT. By C. P. Stacey, B.A., Ph.D. *Royal Empire Society Imperial Studies*, No. 11. Pp. xi + 287, $8\frac{1}{2} \times 5\frac{1}{2}$. (London, New York, Toronto: Longmans, Green & Co., Ltd., 1936.) Price 10*s*. 6*d*.

The author of this book, who is Instructor in History at Princeton University, has traced the history of the military establishments in Canada up to the time when it was finally decided by the British Government that the expense of maintaining a defensive force in the Dominion should be thrown upon the people of Canada itself. The treatise is clearly and interestingly written and in compiling it reference has been made to a very wide field of historical documents, periodicals and volumes by previous authors. It is a useful contribution to the history of the British Commonwealth.

AN OUTLINE OF MALAYAN AGRICULTURE. Compiled by D. H. Grist. *Malayan Planting Manual* No. 2. Pp. xiii + 377, $8\frac{3}{4} \times 5\frac{1}{2}$. (Kuala Lumpur: The Department of Agriculture, Straits Settlements and Federated Malay States, 1936.) Price $3·00.

Scientific agriculture in Malaya has made considerable progress in recent years and an up-to-date authoritative text-book to replace the Malayan "Agricultural Handbook" (published in 1922 and revised in 1924) will be welcomed by all who are interested in, or in any way connected with, the agricultural development of British Malaya. This useful

compilation may be regarded not only as a standard work on the subject of agriculture in Malaya, but also as a valuable work of reference to agriculturists in other tropical countries.

The new book has been entirely rewritten and though certain features of the former publications have been retained, the subject matter has been increased and more conveniently arranged.

The volume contains thirty-three chapters—with references to literature consulted at the end of each—and is divided into six main parts, dealing respectively with Agricultural Conditions, Agricultural Practices, Major Crops, Secondary Crops, Minor Crops and Stock. The major crops dealt with comprise rubber, coconuts, rice, oil palms and pineapples; the secondary crops include tapioca, derris, tea, coffee, tobacco and bananas, whilst under the term minor crops come spices, cereals other than rice, various oil-yielding crops, fibres, drugs, sugar and many others.

In addition to a geological and a general map of Malaya, the book contains eighty-six excellent photographic reproductions.

All About the Soya Bean in Agriculture, Industry and Commerce. By George Douglas Gray, M.D., C.B.E. Pp. viii + 140, $7\frac{1}{4} \times 4\frac{3}{4}$. (London: John Bale, Sons and Danielsson, Ltd., 1936.) Price 7*s.* 6*d.*

Dr. Gray became interested in the subject of soya beans while on medical service in China and he has used the leisure following his retirement in compiling this work, partly from his own observations and partly from other sources.

The book does not set out to be an exhaustive treatise on the cultivation and utilisation of the bean, in fact it is mentioned in the preface that the title originally planned was "The Romance of the Soya Bean," but as it has finally taken shape it fulfils its amended title as well as can be expected in a volume of this size.

The introduction is contributed by Mr. J. L. North, who gives a summary of his pioneer work in growing soya beans in this country. A chapter on the plant and its cultivation contains much useful information regarding varieties of the bean, methods of cultivation practised in different countries, and the possibilities of further developments in England. This is followed by a chapter on the soya bean as food, a subject on which the author writes with authority. The next chapter deals with soya bean oil and its very varied industrial uses. There follows a résumé of the soya bean trade from its origins to its present problems, a chapter on the soya bean in agriculture, and a number of addenda, including statistics, recipes, a bibliography, and other particulars.

The photographs with which the book is illustrated add to its attractiveness.

FLOUR MILLING PROCESSES. By J. H. Scott, B.Sc. Pp. xv + 416, 8½ × 5½. (London: Chapman & Hall, Ltd., 1936.) Price 21*s.*

A complex process such as flour milling, dealing as it does with a raw material of constantly varying quality, makes the acquisition of exact information a very difficult matter and explains in some measure the contradictory views which are met with among millers. Nevertheless, there are many features in the process of which definite and useful information can be obtained by careful investigation. The book under review is, in the main, concerned with the personal experiments of the author and its compilation has extended over eight years. He points out that during this period milling research has developed to such an extent that it is only to be expected that quite a number of the problems dealt with may have been investigated by others more fully, even though the results have not been published. The author hopes, however, that his attempt to present a more or less complete picture of the operations involved in milling and in drawing attention to features which require further investigation, will be of service to those in the industry. The divergence of opinion on the problems involved in the industry is indicated in Sir Ernest Simon's brief Foreword, where he makes it clear that the views expressed in the book are the personal opinions of the author and not necessarily those of the firm of millers with whom Mr. Scott is connected.

The subject matter is divided into two parts, the first of which deals with the treatment of wheat prior to the actual milling processes. It includes chapters on wheat cleaning and preparation, the behaviour of moisture in wheat, wheat conditioning and the bushel weight of wheat. The second part deals with the milling of wheat together with observations and experimental data on the operations involved. Break roll grinding, scalping, grading, purification and flour dressing are among the subjects discussed, while much useful data are given in an Appendix.

This book contains much information, both theoretical and practical, which will be of real value not only to the student of flour milling, but also to the practical flour miller.

MILK: PRODUCTION AND CONTROL. By W. Clunie Harvey, M.D., D.P.H., M.R.San.I., and Harry Hill, M.R.San.I., A.M.I.S.E., M.S.I.A. Pp. viii + 555, 8½ × 5½. (London: H. K. Lewis & Co., Ltd., 1936.) Price 21*s.*

The authors of this volume are respectively Medical Officer of Health and Sanitary Inspector of the Borough of Southgate and their aim has been to bring home to everyone connected

with the handling of liquid milk and not least the consumer, the importance of a clean milk supply. Every aspect of the subject is dealt with and the scope of the work can perhaps best be gauged by an enumeration of the chapter headings: Composition of Milk; Milk and Disease; The Cow; The Cowshed; The Dairy; Clean Milk Production; The Distribution of Milk; Designated Milks; Treatment of Milk by Heat; Laboratory and other Control; Legislative Control; and the Future of the Milk Industry. There are also Appendices containing copies of various forms of licences for issue under the Milk (Special Designations) Order, 1923, and other Regulations; suggested Propaganda Bulletins suitable for distribution to producers, distributors and consumers; and a guide to the preparation of inspection reports.

The very wide field covered naturally precludes a detailed study of some of the aspects of the subject, but, nevertheless, the book as a whole fulfils its purpose very well and it should be particularly helpful to municipal officers and others concerned in keeping up the standard of our food.

HUMUS. Origin, Chemical Composition and Importance in Nature. By Selman A. Waksman. Pp. xi + 494, 9 × 6. (London: Bailliere, Tindall & Cox, 1936.) Price 30s.

This book represents an attempt by a leading American soil micro-biologist to summarise, in the form of a monograph, the available information on the subject of humus. It includes a comprehensive review of the literature as well as an account of the researches carried out over a period of more than 15 years by the author and a number of co-workers at Rutgers University.

The first section of the book gives an historical survey of the development of our knowledge of the chemical nature of humus, its formation and its role in plant nutrition. The author emphasises particularly the complexity of the composition of humus and points out the fallacies of considering "humus" and "humic acid" as definite chemical compounds.

The second section, which is by far the longest of the three main divisions, deals with the origin and nature of humus. This includes chapters on the probable chemical formulæ of some of the known constituents of humus, such as lignin and cellulose; on methods of analysis of humus; and on the chemical nature of humus as a whole. The author then discusses the biology of humus and the processes by which it is formed under various conditions, such as in composts, in forest and mineral soils, in peat and in association with water.

The third section is concerned with the development of

humus, its functions and applications. The author thus finds it convenient in one section to consider humus during its formation and in another section to regard it as a finished product. He realises the difficulties involved in this procedure and comments that such a distinction is purely arbitrary, as the processes of formation and decomposition take place simultaneously. He shows that "humus" has properties sufficiently different from those of the organic matter from which it was derived for it to be recognised as a distinct entity. The final chapters are devoted to a discussion of the properties of humus, its importance to agriculture and particularly its relation to the science of pedology.

There is an appendix giving a brief review of methods of analysis of humus and of certain of its constituents and an extensive bibliography of over 1,300 references.

The plan and nature of the book render it academic rather than practical, but it should be of value to soil chemists and micro-biologists by reason of its up-to-date presentation of the fundamentals of a subject of vital importance to agriculture.

LES ROCHES SÉDIMENTAIRES DE FRANCE. Roches Carbonatées (Calcaires et Dolomies). By Lucien Cayeux. Pp. 447, 12 × 9½. (Paris: Masson et Cie., 1935.) Price 200 *Fr.*

This exhaustive scientific treatise on the sedimentary carbonate rocks of France has been published under the auspices of the administrative council of the Singer-Polignac Foundation and forms a companion volume to the author's *Les roches sédimentaires de France: roches siliceuses.*

The work is divided into two parts. The first, containing more than 300 pages, describes calcareous rocks of marine and lacustrine origin and furnishes details regarding their formation, chemical constitution and physical structures. Thirteen varieties of limestones are discussed from a mineralogical point of view and numerous types are considered in relation to their fossil contents. More than one-half of the first part is devoted to structures occurring in marine limestones, interesting comments being given regarding brecciated, nodular, oolitic, stylolitic and cone-in-cone structures.

The second part contains about 120 pages and deals with dolomitic rocks, including dolomite proper, magnesian limestone and dolomitic sandstones. A detailed account is given of the lithological and chemical aspects of the magnesian chalk of the Paris Basin and special sections deal with structures occurring in dolomites and with the origin of dolomitic rocks generally.

The work is illustrated by 9 text-diagrams and photographs and by 27 excellent plates containing 101 photomicrographs of calcareous and dolomitic rocks. Some idea of the size of the book can be gathered from the fact that it weighs approximately 6½ lb.

THE FINANCIAL POST SURVEY OF MINES. Tenth Annual Edition, 1935-36. Pp. 360, 11⅜ × 8¾. (Toronto; Montreal; New York; London, England: The Maclean Publishing Company, Ltd., 1935.) Price $2.00.

The tenth annual edition of this comprehensive survey of mines and mining operations in Canada and Newfoundland has been considerably enlarged.

It consists mainly of chapters, each devoted to one of the Provinces, in which there is given a review of developments in the Province together with a detailed statement of the affairs of every important company operating a mining property, production statistics and, as a rule, maps of the principal mining areas. Additional chapters deal with Newfoundland, Inactive Companies and Foreign Companies.

The volume also contains much statistical data concerning the mineral production of Canada as a whole, price ranges of Canadian mining stocks, dividends paid by metal mines, price ranges of metals and a list of the principal mining and milling plants in the country. There is an index of names of operating companies and an even more extensive index of inactive companies, the two together covering some 5,000 concerns.

The collection and presentation of this mass of information must have involved an enormous amount of work, and this volume is likely to prove invaluable to any one interested in the development of the mineral industry of the Dominion.

FLOTATION PLANT PRACTICE. By Philip Rabone, A.R.S.M., D.I.C., Assoc.Inst.M.M. Second edition, revised and enlarged. Pp. xv + 165, 8¾ × 6. (London: Mining Publications Ltd., 1936.) Price 10*s.* 6*d.*

The first edition of this useful book, published in 1932, was reviewed in this BULLETIN, 1933, **31**, 132. The second edition, while retaining most of the original subject matter, has been completely revised and enlarged by 24 pages, due largely to the expansion of sections dealing with flotation machines, flotation methods and grinding. Among the new material incorporated in the work are descriptions of the Kraut, Fagergren and Geco new-cell machines, more recent data regarding the Minerals Separation sub-aeration machine,

an interesting table (compiled from information supplied by the British Tyre & Rubber Co., Ltd.) showing the capacities and power requirements of belt conveyors, an appendix giving the minimum advisable launder slopes and power required for pumping water, and new block-diagrams of apron feeders, Hum-mer vibrating screens and vibrators, and Geco automatic electric samplers. The section on the flotation of gold ores has been rewritten in consequence of important developments that have taken place during the past few years.

The work can be recommended to all interested in flotation problems and practice in general.

MODERN USES OF NON-FERROUS METALS. Edited by C. H. Mathewson. First Edition. Pp. x + 427, 8 × 5¼. (New York: The American Institute of Mining and Metallurgical Engineers, 1935.) Price $3·00.

This book has been compiled with the intention of providing the young engineer with a readily comprehensive account of the modern metal industry, particularly with reference to alloys. The various contributors are to be congratulated upon the thorough yet concise manner in which the work has been written. While the title excludes ferrous-metallurgy proper, the subject is prominent in the sections dealing with chromium, cobalt, the miscellaneous alloy metals, molybdenum, nickel, tungsten and vanadium, and in fact may be said to constitute a dominant theme in the book.

The various metals, precious and non-precious, are treated in alphabetic order, except in closely-linked pairs such as zinc and cadmium, tantalum and columbium and the group of miscellaneous alloy-forming elements dealt with in chapter ten; and in addition to uses, where appropriate, adequate accounts are given of the history of the production of each metal.

An introductory chapter passes from a brief description of earth-structure and the relative proportion of metals in the crust, to ferrous and non-ferrous metals—their differences and characteristics—and to the properties of metals and alloys. Here, perhaps, plates illustrating typical austenitic, pearlitic and ferritic steels and the usual forms, sorbite, troostite and martensite, would have served a useful purpose, especially as these are frequently referred to subsequently.

Aluminium is the first metal considered and after a brief historical review of the preparation of the metal, the alloys are dealt with and particular mention is made of the work of Dr. Pacz on the aluminium-silicon alloys. The chapter concludes with an account of the applications of the metal and various alloys.

The other metals are treated more or less in similar fashion and, as is unavoidable in a work of this character, with reference to particular alloys such as the stainless steels, lead-antimony cable-sheathing alloys, bronzes and brasses, repetition is prevalent but commendably accurate and consistent.

The precious metals, and notably those of the platinum group, are excellently described, and many useful graphs and tables of physical properties are given, as well as certain interesting plates of the uses to which these metals are put.

More than thirty metals in all are covered in the book and a valuable index has also been included.

A KEY TO PRECIOUS STONES. By L. J. Spencer, C.B.E., M.A., Sc.D., F.R.S., F.G.S., F.C.S., F.R.G.S. Pp. vi + 237, $7\frac{1}{4} \times 5$. (London and Glasgow: Blackie & Son, Ltd., 1936.) Price 5*s*.

This useful little book by a well-known mineralogist contains an account, written as far as possible in popular language, of precious stones, their properties and composition, their occurrence in nature and their uses. The viewpoint adopted is essentially that of the mineralogist and "romance and mystery and feelings of æsthetic rapture, often associated with gem-stones, are kept in the background."

The first part deals, in 108 pages, with general principles and the remainder of the book is devoted to descriptions of all the important stones used for gem purposes and of some that are very seldom so employed, including a few that have slender claims for consideration in such company.

The section on general principles deals not only with the optical and other physical properties of gemstones, but contains chapters on chemical composition, geological occurrence and origin, mining, cutting, imitations and nomenclature. It is unusual in a book of this kind to find such a detailed account of the forms of crystals and of crystal optics as has been compressed into 38 pages in this work. It is no mean achievement to have presented so complex a subject in so brief a space, but it is doubtful whether the greater part of these chapters will be comprehensible to the ordinary reader and a simplified statement would have been more appropriate.

The book is written almost throughout in an easy conversational style with many quips and amusing comments, several of which are directed against jewellers and gem dealers, while others are merely cynical. For example, after contending that artificially produced rubies, sapphires, etc., are real and natural as those found in the rocks, Dr. Spencer remarks that the action of Verneuil in generously giving to the world the results of his research work "was surely a case

of casting pearls before swine." Again, after the statement that amethyst has been regarded as a charm against intoxication, we are told that "for this reason bishops, whose duties take them to public functions of all sorts, wear an amethyst in the episcopal ring" and this is followed by a digression on the derivation of the word alcohol. In discussing pearls (p. 230) the author remarks that "the tomb of a parasitic worm is not a really pleasant object with which to bedeck a fair neck."

The book is illustrated with eight plates and many excellent line drawings, but the principal illustration is a coloured plate of 29 gemstones which, rather curiously, appears on the dustjacket.

Incidentally, it is incorrectly stated in the preface that the publication on gemstones issued by the Imperial Institute is a guide-book to a collection, whereas, in fact, it is a general report with special reference to Empire occurrences.

Considering the wealth of detail it contains and in spite of the rather narrow viewpoint adopted, this little book is an outstanding production and a very cheap one. It will be found to provide the interested reader with most of the scientific data concerning gemstones that he is likely to require.

LE KIESELGUHR. By Jules Vanden Broeck. Pp. 114, 10 × 6½. (Paris: Société des Silices Fossiles de France, 1935.) Price 25 *fr.*

It is stated in the preface that this book was written with the sole object of furthering the uses of kieselguhr or diatomaceous earth. Nearly half of the text, however, is devoted to descriptions of diatoms, minute aquatic plants the skeletal remains of which constitute kieselguhr. Very brief accounts are given of the formation of deposits of kieselguhr, its chemical constitution, microscopic examination, density, porosity and other physical characters.

The second part of the book (pp. 75-114) gives a useful summary of the many uses to which kieselguhr is put. It deals first with insulation against heat in the form of bricks, powder, plastic lagging compositions, moulded blocks and twine; and next with the use of kieselguhr in filtration.

Here it is pointed out that in spite of all that has been written on the subject of the type of diatom which is most suitable for filtration, this forms but a secondary consideration, the main necessity being the freedom of the earth from impurities, especially clay. The filtration of sugar solutions, mineral and vegetable oils, wax, gelatine, glue, wines, fruit juices and varnish all receive attention.

An account of the use of kieselguhr as an admixture in cement, concrete and plaster occupies eight pages and includes

the results of several tests which bear out the contention that the addition of kieselguhr to concrete mixtures improves the workability, homogeneity and impermeability of the product.

Four pages of minor uses complete the book. Kieselguhr is sometimes used as a filler in rubber goods, soap and many other products, as an absorbent of explosive mixtures and dissolved acetylene, in printing ink and match-heads, as a support for catalysts, as an ingredient in many types of polishing compounds, insecticides and jointless flooring mixtures and for many other purposes.

The book does not treat of the distribution of kieselguhr, its production and preparation for market, nor is there any account of the trade in this product or the price it commands.

SULFURIC ACID MANUFACTURE. By Andrew M. Fairlie. (American Chemical Society Monograph Series.) Pp. 669, 9 × 6. (New York: Reinhold Publishing Corporation; London: Chapman & Hall, Ltd., 1936.) Price 48*s*. 6*d*.

The object of the author of this work, as stated in the preface, has been to produce a book on sulphuric acid manufacture which would be of practical use to the chemical engineer, the technical chemist, the acid manufacturer, the college student and the acid consumer without clogging the text with lengthy descriptions of obsolete processes or of proposals that have not been reduced to practice. The endeavour is made, also, to present up-to-date information, in a readily accessible form, within the compass of a single volume, so that the work would be of a size adaptable for revision as frequently as advances in the industry may require.

Both the chamber and contact processes of sulphuric acid manufacture are thoroughly considered and much useful information is given regarding the materials and methods at present employed in the industry. Two interesting chapters deal respectively with catalysts and with the comparison of platinum and vanadium catalysts, the advantages and disadvantages of each type being summarised.

The book treats largely of American practice, but this is claimed to be justified by the progress that has taken place in America in the contact processes during the last decade and to the lack of consideration of American practice in books on sulphuric acid published in other countries. The information given, however, will in any case be of much interest to those in this country connected with the sulphuric acid industry.

Though the book does not profess to be exhaustive, it cannot be regarded in any way as elementary and, with the

many references to sources of other information which are given, will be welcomed as a concise and readable account of the technology of this important manufacture.

SPECTRUM ANALYSIS WITH THE CARBON ARC CATHODE LAYER ("Glimmschicht"). A Method developed by Professor V. M. Goldschmidt, Dr. R. Mannkopff and their co-workers at Göttingen and applicable to non-conducting solids and powders. By Lester W. Strock, Ph.D. With a preface by Professor V. M. Goldschmidt. Pp. 56, $9\frac{1}{2} \times 6$. (London: Adam Hilger, Ltd., 1936.)

Geochemical investigations in recent years have been mainly directed towards the distribution of the minor chemical constituents of rocks and minerals. The quantities to be determined, however, are usually so small that chemical methods have been largely supplanted by physical ones. The method of X-ray spectrum analysis invented by Professor A. Hadding at Lund, Sweden, has given good service, but Professor V. M. Goldschmidt and his co-workers at Göttingen have developed the method described in this publication. In addition to their great sensitivity, the physical methods enable systematic quantitative analyses of large numbers of specimens to be carried out with comparative rapidity.

The cathode layer or "Glimmschicht" method is stated to have been successfully employed by V. M. Goldschmidt and his students in thousands of analyses of rocks, minerals, etc., and its high degree of sensitivity has made possible the discovery of many previously unknown associations of elements with one another or with certain minerals in nature. It is claimed that by this method, wherein the substance is vaporised from the cathode, smaller quantities of most elements can be determined than by the spark or earlier arc methods. No previous treatment other than powdering is required and only a few milligrammes of material are necessary. It is further claimed that most metals can be determined in concentrations down to 0·0005 per cent. and that in some instances 10 to 20 times this sensitivity has been observed.

The author has spent several years as a visiting investigator at the Göttingen laboratories, during which time he has sought to make improvements in methods. In consequence, he is able to present an authoritative and coherent summary of the method and its application to geochemical problems, which will be of interest to those concerned with rapid spectrographic analyses of such non-conducting powders as those of rocks, minerals, glasses, slags, ashes, clays, soils, etc. The book is illustrated by photographs of apparatus as well as by line diagrams and curves.

INTRODUCTION TO THE MICROTECHNIQUE OF INORGANIC QUALITATIVE ANALYSIS. By A. A. Benedetti-Pichler, Dr.techn.Sc., and W. F. Spikes, M.S. Pp. viii + 180, 9 × 6. (Douglaston, N.Y.: Microchemical Service, 1935.) $3.00.

Since 1930, Washington Square College of New York University has provided an undergraduate course of instruction in inorganic microchemical analysis; the laboratory manual used in this course has now been expanded and published. As the origin and the title of the book suggest, it is essentially practical in treatment, and although intended for degree students, chemists in this country will find it of considerable interest.

Methods of manipulation, which are often very ingenious, are described in detail and a scheme for the separation and detection on a micro scale, of the commonly occurring elements, is included. Many references to the original literature are given enabling the student to pursue his studies further. Spaces are provided for the student to sketch the characteristic appearance under the microscope of compounds used in identification. While this is a good method of teaching when a skilled instructor is available, the book would have been of more use to the busy commercial analyst if illustrations of the results obtained by the authors had also been included.

The student is encouraged to make a rough quantitative estimate of the relative proportions of constituents during a qualitative examination. It is also emphasised in the introduction that the directions for carrying out recommended procedures should be followed closely, but this is rendered difficult in many cases by defining, in terms of the size of a poppy seed, the amount of a crystal of solid reagent to be added. A better known and more definite standard of size would have been preferable.

It is interesting to note that kinematograph films illustrating practical details are shown during the authors' course of lectures. This excellent aid to teaching should be more widely used, as demonstrations given in this way can be carried through in a very short time, are easy to follow and never fail.

CHEMICAL SYNONYMS AND TRADE NAMES. By William Gardner. Pp. 495, 9½ × 6. Fourth Edition. (London: The Technical Press, Ltd., 1936.) Price 31*s.* 6*d.*

The number of names of chemical substances and preparations is now so vast and fresh names are so constantly being coined, that it is impossible for anyone to be a "walking dictionary" even within a specialist's limited field. The

advantage of being able to turn to such a book of reference as this is, therefore, very great.

It is evident that in a compilation of this sort everything depends on being able to rely on the accuracy of each item of information without having to check it from other sources, even supposing other sources to be available, and there is every indication that the author has taken considerable pains to secure this end.

Following the main body of the work is an additional section comprising more than a quarter of the volume. Most of the names in this section are supplementary to those in the main work, but in some cases items are repeated with additional information. It seems a pity that both sections could not have been incorporated in one.

POISONS LAW. By Hugh N. Linstead. Pp. 444, $8\frac{1}{4} \times 5\frac{1}{2}$. (London: The Pharmaceutical Press, 1936.) Price 5*s*.

The author of this volume, who is the Secretary of the Pharmaceutical Society of Great Britain, explains in the Preface that the book has been written at the request of his Council, for the use of those carrying on business as chemists and druggists, and that its scope has been extended in the hope that it may also be useful to medical practitioners, pharmaceutical manufacturers and others concerned in the sale or dispensing of poisons. A chapter on "The International Background to the Dangerous Drug Acts" is contributed by Sir Malcolm Delevingne, late British representative on the Opium Advisory Committee of the League of Nations.

The provisions of the Pharmacy and Poisons Act, 1933, and the Dangerous Drugs Acts and Regulations, 1929-1932, are very fully discussed in their relations to the pharmaceutical industry, while about one-half the book is occupied by two Appendices containing respectively the text of the various Statutes, Rules, etc., and a list of poisons and substances containing poisons, with an indication of the special restrictions applying to each.

The book is well arranged in a clear and practical manner and should prove of much value to those for whom it is intended.

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REPORTS OF RECENT INVESTIGATIONS AT THE IMPERIAL INSTITUTE

Selected from the Reports made to the Dominion, Indian, and Colonial Governments

SHEA NUTS FROM THE GOLD COAST

For some years past an investigation has been in progress by the Imperial Institute, in conjunction with the Department of Forestry, Nigeria, and the Department of Agriculture, Gold Coast, with a view to determining whether any definite varieties of Shea trees exist in those countries, and whether there are any differences in the yield and quality of the fat obtained from nuts derived from individual trees. Reports dealing with three series of nuts from Nigeria have already been published (this Bulletin, 1930, **28**, 123; 1931, **29**, 407; 1933, **31**, 334) as well as a report on a series from the Gold Coast (1932, **30**, 282). In the following pages are given the results of examination of a further series of twenty-one samples of the nuts from the Gold Coast, forwarded by the Director of Agriculture in August, 1935.

The nuts had been obtained during the fruiting season of 1935 from the same trees on the Yendi Shea Reserve from which the samples previously examined had been derived. The trees had been chosen to represent as great a range of variation as possible, especially in respect of bark formation and leaf shape. A brief description of the trees was given in the previous report (this Bulletin, 1932, **30**, 282-283).

Description

The general characters of the samples are recorded in the following table:—

Label.	Weight.	Description of Nuts.	Colour of Nuts.	Dimensions of Nuts.	Internal Colour of Kernels, etc.	Dimensions of Kernels.
	oz.			*inches.*		*inches.*
T5	11	Small to medium. Mostly blunt; some rather pointed.	Golden-brown.	0·9×0·7 to 1·2×1·0. Mostly 1·0×0·9.	Buff to dark purplish-red; mostly pale pinkish-brown. Some covered with mould.	0·6×0·5 to 1·0×0·8. Mostly 0·9×0·6.
T6	9	Small to medium; mostly medium. Mostly rather pointed. Bad insect attack.	Dull yellowish-brown.	0·9×0·75 to 1·4×1·1. Mostly 1·1 to 1·3×1·0.	Buff to dark chocolate-brown; mostly pale pinkish-brown to chocolate-brown. Some covered with mould.	0·65×0·5 to 1·2×0·8. Mostly 1·0×0·7.
T8	18	Medium. Pointed. Some insect attack.	Golden-brown.	1·0×0·6 to 1·4×0·9. Mostly 1·3×0·9.	Buff to dark chocolate-brown; mostly buff to pinkish-brown. Some covered with mould.	0·85×0·5 to 1·3×0·8. Mostly 1·1×0·7.
T9	2¾	Small to large; mostly medium. Some blunt; some rather pointed. Some insect attack.	Yellowish-brown to golden-brown; mostly golden-brown.	0·9×0·8 to 1·5×1.2. Mostly 1·0×0·8 to 1·2×0·9.	Buff to chocolate-brown; mostly buff to pinkish-brown. Many covered with mould.	0·75×0·6 to 1·25×0·9. Mostly 0·8×0·7 to 1·0×0·75.
T10	14	Medium. Blunt. Bad insect attack.	Buff to yellowish-brown; mostly yellowish-brown. Dull.	1·0×0·9 to 1·4×1·1. Mostly 1·1×1·0.	Buff to dark chocolate-brown; mostly buff to brown. Many covered with mould.	0·8×0·6 to 1·1×0·8. Mostly 1·0×0·75.
T11	5	Small to large; mostly medium. Rather pointed. Slight insect attack.	Yellowish-brown to reddish-brown; mostly reddish-brown.	0·9×0·8 to 1·3×1.1. Mostly 1·1×0·9.	Buff to dark chocolate-brown; mostly pinkish-brown.	0·7×0·55 to 1·1×0·8. Mostly 0·95×0·7.
T12	38	Very small to medium; mostly medium. Rather pointed. Slight insect attack.	Golden-yellow to dark brown; mostly golden-brown.	0·75×0·6 to 1·2×0·9. Mostly 1·1×0·8.	Pale pinkish-brown to very dark chocolate-brown; mostly pinkish-brown. Some covered with mould.	0·7×0·55 to 1·0×0·7. Mostly 0·9×0·6.

Label.	Weight.	Description of Nuts.	Colour of Nuts.	Dimensions of Nuts.	Internal Colour of Kernels, etc.	Dimensions of Kernels.
	oz.			inches.		inches.
T13	28	Very small to medium. Rather pointed. Slight insect attack.	Golden-yellow to golden-brown; mostly golden-brown.	0·75×0·6 to 1·3×0·9. Mostly 1·0×0·8.	Buff to very dark chocolate-brown; mostly pale pinkish-brown. A few covered with mould.	0·6×0·4 to 1·1×0·7. Mostly 0·9×0·6.
T15	28	Small to medium. Mostly blunt; some rather pointed. Bad insect attack.	Buff to golden-brown; mostly buff to pale golden-brown.	0·8×0·7 to 1·3×1·0. Mostly 1·0×0·9.	Buff to very dark chocolate-brown; mostly pinkish-brown. Some covered with mould.	0·7×0·5 to 1·0×0·7. Mostly 0·8×0·65.
T16	18	Small to large; mostly medium. Mostly blunt; some rather pointed. Some insect attack.	Buff to golden-brown; mostly golden-brown.	0·9×0·75 to 1·5×1·1. Mostly 1·1 to 1·2×1·0.	Do.	0·8×0·55 to 1·3×0·8. Mostly 0·9×0·7.
P1	11	Very small to medium; mostly medium. Mostly blunt. Some insect attack.	Buff to brown; mostly golden-brown.	0·7×0·6 to 1·2×0·9. Mostly 1·0×0·9.	Buff to very dark chocolate-brown; mostly buff to pale pinkish-brown. A few covered with mould.	0·6×0·5 to 1·0×0·65. Mostly 0·8×0·6.
P2	38	Small to large; mostly medium. Mostly rather pointed; some blunt. Bad insect attack.	Buff to dark brown; mostly golden-yellow to golden-brown. Rather mixed appearance.	0·9×0·6 to 1·5×1·2. Mostly 1·1 to 1·2×0·9 to 1·0.	Similar to P1, but more kernels covered with mould.	0·65×0·4 to 1·1×0·85. Mostly 1·0×0·75.
P 3	46	Small to medium; mostly medium. Mostly blunt; some rather pointed. Bad insect attack.	Golden-brown. A few buff.	0·9×0·75 to 1·3×1·1. Mostly 1·1×0·9.	Buff to dark chocolate-brown; mostly pinkish-brown. A few covered with mould.	0·8×0·6 to 1·0×0·9. Mostly 1·0×0·7.

Label.	Weight.	Description of Nuts.	Colour of Nuts.	Dimensions of Nuts.	Internal Colour of Kernels, etc.	Dimensions of Kernels.
	oz.			inches.		inches.
P6	6	Small to medium; mostly small. Some rather pointed; others blunt.	Golden-yellow to golden-brown; mostly golden-yellow.	0·8×0·7 to 1·2×0·9. Mostly 0·9 to 1·0×0·7 to 0·8.	Buff to chocolate-brown; mostly pinkish-brown. Many covered with mould.	0·65×0·45 to 0·9×0·7. Mostly 0·8×0·6.
D	2½	Very small to small; mostly very small. Pointed. Slight insect attack.	Golden-brown.	0·6×0·4 to 1·0×0·75. Mostly 0·8×0·6.	Buff to chocolate-brown; mostly pale pinkish-brown. A few covered with mould.	0·5×0·4 to 0·9×0·5. Mostly 0·7×0·5.
D2	8	Small to medium; mostly small. Mostly pointed. Slight insect attack.	Golden-yellow to golden-brown; mostly golden-brown.	0·8×0·7 to 1·1×0·95. Mostly 0·9 to 1·0×0·7 to 0·8.	Similar to D, but more kernels covered with mould.	0·65×0·5 to 0·9×0·8. Mostly 0·8 to 0·9×0·6.
E	46	Small to medium; mostly medium. Mostly blunt; some rather pointed. Slight insect attack.	Buff to golden-brown; mostly golden-yellow.	0·8×0·7 to 1·3×1·1. Mostly 1·1×0·9.	Buff to chocolate-brown; mostly pinkish-brown. Some covered with mould.	0·75×0·6 to 1·1×0·85. Mostly 0·9×0·7.
R	108	Very small to medium; mostly small. Mostly blunt. Slight insect attack.	Golden-yellow to golden-brown; mostly golden-brown.	0·75×0·65 to 1·1×0·95. Mostly 0·9 to 1·0×0·8.	Buff to very dark chocolate-brown; mostly pinkish-brown. A few covered with mould.	0·6×0·5 to 0·9×0·7. Mostly 0·8×0·7.
X3	94	Very small to medium; mostly medium. Pointed.	Uniform colour; light golden-brown.	0·75×0·55 to 1·3×1·0. Mostly 1·1×0·9.	Buff to dark chocolate-brown; mostly pinkish-brown. Some covered with mould.	0·6×0·4 to 1·1×0·7. Mostly 0·9×0·6.
X37	32	Small to medium; mostly medium. Blunt or rather pointed. Bad insect attack.	Buff to golden-brown; mostly golden-brown.	0·9×0·7 to 1·2×1·0. Mostly 1·0 to 1·1×0·9.	Do.	0·6×0·5 to 1·0×0·8. Mostly 0·9×0·6.
X66	6½	Small to medium; mostly medium. Mostly blunt. Bad insect attack.	Pale yellowish-brown to golden-brown; mostly golden-yellow to golden-brown.	1·0×0·8 to 1·1×1·0. Mostly 1·0 to 1·1×0·8 to 0·9.	Do.	0·7×0·5 to 0·95×0·7. Mostly 0·9×0·6.

Results of Examination

The samples were submitted to detailed examination and the results are recorded in Tables I to VI. Table I gives the relative weights and composition of the nuts as received at the Imperial Institute, the amounts of oil which they contained and the percentages of unsaponifiable matter in the oil, together with corresponding figures for nuts of the 1931 crop from the same trees (this BULLETIN, 1932, **30**, 288). Tables II to VI show the correlation of the unsaponifiable matter with other factors.

Remarks

The following observations may be made upon the results of the examination of these 21 samples of shea nuts from Yendi.

(1) The percentage of kernels in the nuts varies from 63·5 to 80·3, with an average of 70·0. In 16 samples the range is narrower still, being from 67·5 to 73·0 per cent. (Tables I and II).

(2) The kernels as received contain from 42·6 to 52·7 per cent. of oil, with an average of 48·7. For 18 samples the oil content falls within a range of 5 per cent., viz. from 47·7 to 52·7 (Tables I and II).

(3) The oil content expressed on the moisture-free kernels varies from 47·1 to 56·9 per cent., with an average of 53·1. For 19 samples the figures range from 51·5 to 56·9 per cent. (Tables I and III).

(4) Sample X3 gives the highest percentage of oil from the kernels and T13 the lowest (both expressed on the moisture-free material).

The average oil content of the T samples (52·4 per cent. expressed on the moisture-free kernels) is similar to that of the P samples (52·8 per cent.),[1] but the oils of the P samples contain on the average less unsaponifiable matter, i.e. 4·5 against 5·3 per cent. (Table I).

(5) There is a slight indication of a relationship between the percentage of kernels in the nuts and the percentage of oil in the kernels as received. A high kernel content is often associated with a high oil content. The relationship is not

[1] In the previous series, the P samples were on the whole richer in oil than the T samples.

TABLE I

Sample	T5 1935	T5 1931	T6 1935	T6 1931	T8 1935	T8 1931	T9 1935	T9 1931	T10 1935	T10 1931	T11 1935	T11 1931	T12 1935	T12 1931	T13 1935	T13 1931	T15 1935	T15 1931	T16 1935	T16 1931
Average weight of a nut *grams*	4·0	3·9	5·4	4·2	4·5	3·7	3·9	3·9	4·7	3·6	4·8	4·0	3·0	3·8	2·9	4·6	3·5	4·0	4·8	5·4
Average weight of a kernel *grams*	2·8	2·5	3·5	3·0	3·1	2·6	3·1	2·7	3·2	2·5	3·3	2·7	2·0	2·6	2·0	3·2	2·4	2·8	3·4	3·7
Kernel in nuts *per cent.*	71·1	65·0	65·9	71·0	67·7	69·3	80·3	67·5	68·0	68·3	70·2	67·3	68·5	67·5	68·2	70·0	67·6	69·5	72·3	69·0
Shell in nuts *per cent.*	28·9	35·0	34·1	29·0	32·3	30·7	19·7	32·5	32·0	31·7	29·8	32·7	31·5	32·5	31·8	30·0	32·4	30·5	27·7	31·0
Moisture in kernels *per cent.*	8·8	7·3	10·4	6·0	8·5	5·9	8·5	6·3	9·6	5·9	8·7	6·5	7·5	5·9	8·7	6·0	8·1	6·1	8·2	6·2
Oil in kernels, as received *per cent.*	50·4	38·8	42·6	48·4	48·9	48·4	49·3	46·9	47·7	48·3	48·1	44·0	47·9	49·1	43·0	51·5	49·8	49·2	51·1	48·1
Oil expressed on moisture-free kernels *per cent.*	55·3	41·9	47·5	51·5	53·4	51·4	53·9	50·1	52·8	51·3	52·7	47·1	51·8	52·2	47·1	54·8	54·2	52·4	55·7	51·3
Oil expressed on nuts *per cent.*	35·8	25·2	28·1	34·4	33·1	33·5	39·6	31·7	32·4	33·0	33·8	29·6	32·8	33·1	29·3	36·0	33·7	34·2	36·9	33·2
Unsaponifiable matter in oil *per cent.*	4·4	8·9	8·3	6·0	5·1	4·9	4·6	5·9	4·9	5·1	4·3	5·5	5·3	5·3	7·0	6·0	4·4	4·7	4·7	4·4

TABLE 1—*continued*.

Sample	P1		P2		P3		P6		D		D2		E		R		X3		X37		X66	
	1935	1931	1935	1931	1935	1931	1935	1931	1935	1931	1935	1931	1935	1931	1935	1931	1935	1931	1935	1931	1935	1931
Average weight of a nut *grams*	3·4	3·5	4·3	3·6	4·7	5·7	3·2	3·3	1·9	3·6	2·8	2·7	4·1	4·0	3·3	3·7	3·8	4·7	3·6	3·5	3·5	5·0
Average weight of a kernel *grams*	2·5	2·3	2·9	2·5	3·2	4·1	2·2	2·2	1·4	2·5	2·0	1·8	3·0	2·8	2·3	2·5	3·0	3·1	2·5	2·4	2·3	3·7
Kernel in nuts *per cent.*	72·5	66·0	63·5	68·3	67·5	71·0	69·6	67·0	71·4	67·5	70·5	67·5	73·0	70·3	69·3	68·8	76·9	66·3	69·4	69·0	65·7	73·5
Shell in nuts *per cent.*	27·5	34·0	36·5	31·7	32·5	29·0	30·4	33·0	28·6	32·5	29·5	32·5	27·0	29·7	30·7	31·2	23·1	33·7	30·6	31·0	34·3	26·5
Moisture in kernels *per cent.*	8·5	5·7	13·4	6·2	8·2	6·0	7·5	6·6	6·7	6·3	6·9	5·6	7·6	6·3	7·2	6·4	7·4	5·8	7·5	7·1	7·4	6·1
Oil in kernels as received *per cent.*	48·2	52·8	44·6	47·6	49·2	49·1	49·4	50·1	50·8	48·9	49·9	51·0	49·3	47·8	50·8	47·9	52·7	49·3	50·1	43·6	47·9	49·7
Oil expressed on moisture-free kernels *per cent.*	52·7	56·0	51·5	50·8	53·6	52·2	53·4	53·6	54·5	52·2	53·6	54·0	53·3	51·0	54·8	51·2	56·9	52·3	54·2	46·9	51·7	52·9
Oil expressed on nuts *per cent.*	34·9	34·8	28·3	32·5	33·2	34·9	34·4	33·6	36·3	33·0	35·2	34·4	36·0	33·6	35·2	33·0	40·5	32·7	34·8	30·1	31·5	36·5
Unsaponifiable matter in oil *per cent.*	4·3	4·9	4·9	5·3	4·7	6·4	4·1	5·2	4·8	7·3	4·9	5·3	4·7	5·4	3·7	4·8	3·6	5·6	4·9	4·3	5·4	3·5

TABLE II

Relation of percentage of kernels in nuts to percentage of oil (expressed on kernels as received and on moisture-free kernels) and to percentage of unsaponifiable matter in oil.

Sample.	Kernels in nuts.	Oil in kernels as received.	Oil expressed on moisture-free kernels.	Unsaponifiable matter in oil.
	Per cent.	Per cent.	Per cent.	Per cent.
T9	80·3	49·3	53·9	4·6
X3	76·9	52·7	56·9	3·6
E	73·0	49·3	53·3	4·7
P1	72·5	48·2	52·7	4·3
T16	72·3	51·1	55·7	4·7
D	71·4	50·8	54·5	4·8
T5	71·1	50·4	55·3	4·4
D2	70·5	49·9	53·6	4·9
T11	70·2	48·1	52·7	4·3
P6	69·6	49·4	53·4	4·1
X37	69·4	50·1	54·2	4·9
R	69·3	50·8	54·8	3·7
T12	68·5	47·9	51·8	5·3
T13	68·2	43·0	47·1	7·0
T10	68·0	47·7	52·8	4·9
T8	67·7	48·9	53·4	5·1
T15	67·6	49·8	54·2	4·4
P3	67·5	49·2	53·6	4·7
T6	65·9	42·6	47·5	8·3
X66	65·7	47·9	51·7	5·4
P2	63·5	44·6	51·5	4·9

TABLE III

Relation of percentage of oil, expressed on the moisture-free kernels, to percentage of unsaponifiable matter in oil.

Sample.	Oil expressed on moisture-free kernels.	Unsaponifiable matter in oil.	Sample.	Oil expressed on moisture-free kernels.	Unsaponifiable matter in oil.
	Per cent.	Per cent.		Per cent.	Per cent.
X3	56·9	3·6	P6	53·4	4·1
T16	55·7	4·7	E	53·3	4·7
T5	55·3	4·4	T10	52·8	4·9
R	54·8	3·7	P1	52·7	4·3
D	54·5	4·8	T11	52·7	4·3
X37	54·2	4·9	T12	51·8	5·3
T15	54·2	4·4	X66	51·7	5·4
T9	53·9	4·6	P2	51·5	4·9
D2	53·6	4·9	T6	47·5	8·3
P3	53·6	4·7	T13	47·1	7·0
T8	53·4	5·1			

TABLE IV

Relation of percentage of oil in nuts to percentage of unsaponifiable matter in oil.

Sample.	Oil in nuts.	Unsaponifiable matter in oil.	Sample.	Oil in nuts.	Unsaponifiable matter in oil.
	Per cent.	Per cent.		Per cent.	Per cent.
X3	40·5	3·6	T11	33·8	4·3
T9	39·6	4·6	T15	33·7	4·4
T16	36·9	4·7	P3	33·2	4·7
D	36·3	4·8	T8	33·1	5·1
E	36·0	4·7	T12	32·8	5·3
T5	35·8	4·4	T10	32·4	4·9
D2	35·2	4·9	X66	31·5	5·4
R	35·2	3·7	T13	29·3	7·0
P1	34·9	4·3	P2	28·3	4·9
X37	34·8	4·9	T6	28·1	8·3
P6	34·4	4·1			

TABLE V

Relation of average weight of a kernel to percentage of unsaponifiable matter in oil.

Sample	Average weight of a kernel. Grams.	Unsaponifiable matter in oil. Per cent.	Sample.	Average weight of a kernel. Grams.	Unsaponifiable matter in oil. Per cent.
T6	3·5	8·3	X37	2·5	4·9
T16	3·4	4·7	P1	2·5	4·3
T11	3·3	4·3	T15	2·4	4·4
T10	3·2	4·9	R	2·3	3·7
P3	3·2	4·7	X66	2·3	5·4
T8	3·1	5·1	P6	2·2	4·1
T9	3·1	4·6	T12	2·0	5·3
E	3·0	4·7	D2	2·0	4·9
X3	3·0	3·6	T13	2·0	7·0
P2	2·9	4·9	D	1·4	4·8
T5	2·8	4·4			

TABLE VI

Average percentage of unsaponifiable matter, expressed on the kernels as received, on the moisture-free kernels, and on the nuts.

				Unsaponifiable matter, expressed on		
Sample.	Oil in kernels as received. Per cent.	Oil expressed on moisture-free kernels. Per cent.	Unsaponifiable matter in oil. Per cent.	Kernels as received. Per cent.	Moisture-free kernels. Per cent.	Nuts. Per cent.
X3	52·7	56·9	3·6	1·90	2·05	1·46
T16	51·1	55·7	4·7	2·40	2·62	1·73
D	50·8	54·5	4·8	2·44	2·62	1·74
R	50·8	54·8	3·7	1·88	2·03	1·30
T5	50·4	55·3	4·4	2·22	2·43	1·58
X37	50·1	54·2	4·9	2·46	2·66	1·71
Average (50 per cent. of oil and over)	51·0	55·2	4·4	2·21	2·40	1·59
D2	49·9	53·6	4·9	2·45	2·63	1·73
T15	49·8	54·2	4·4	2·19	2·39	1·48
P6	49·4	53·4	4·1	2·03	2·19	1·41
T9	49·3	53·9	4·6	2·27	2·48	1·82
E	49·3	53·3	4·7	2·32	2·51	1·69
P3	49·2	53·6	4·7	2·31	2·52	1·56
T8	48·9	53·4	5·1	2·49	2·72	1·69
P1	48·2	52·7	4·3	2·07	2·27	1·50
T11	48·1	52·7	4·3	2·07	2·27	1·45
T12	47·9	51·8	5·3	2·54	2·75	1·74
X66	47·9	51·7	5·4	2·59	2·79	1·70
T10	47·7	52·8	4·9	2·34	2·59	1·59
Average (45-49·9 per cent. of oil)	48·8	53·1	4·7	2·31	2·51	1·61
P2	44·6	51·5	4·9	2·19	2·52	1·39
T13	43·0	47·1	7·0	3·01	3·30	2·05
T6	42·6	47·5	8·3	3·54	3·94	2·33
Average (42·6-44·9 per cent. of oil)	43·4	48·7	6·7	2·91	3·25	1·92

so marked when the percentage of kernels in the nuts is compared with the oil percentage expressed on the moisture-free kernels (Table II). This relationship was not shown in the previous series.

(6) The percentage of unsaponifiable matter in the oils varies from 3·6 to 8·3 per cent., with an average of 4·9. For 17 samples the figures lie between 4 and 6 per cent.

The oil from T6 contains the largest proportion of unsaponifiable matter, and that from X3 the lowest (Table I).

(7) There seems to be a slight indication that (*a*) the larger the percentage of kernels in the nuts the lower is the content of unsaponifiable matter in the oil, and (*b*) the higher the oil content of the kernels the less unsaponifiable matter the oil contains. For example, sample X3, the oil of which contains the least unsaponifiable matter, shows the highest proportion of kernels in the nuts (T9 only excepted), and contains the most oil. Sample T6, the oil of which contains the highest percentage of unsaponifiable matter, shows the lowest yield of kernels in the nuts (X66 and P2 only excepted), and contains the least oil expressed on the material as received, but when the oil content is calculated on the moisture-free kernels, P2 has a slightly lower figure (Tables II and IV). Neither (*a*) nor (*b*) were shown in the previous series.

(8) In Table VI the percentage of unsaponifiable matter in the oil is shown in comparison with the amount of oil in the kernels. The average results for the groups show a tendency for the samples yielding more oil from the kernels to contain a lower percentage of unsaponifiable matter in the oil. The figures for each group expressing the average percentage of unsaponifiable matter in the kernels as received, in the moisture-free kernels and in the nuts, are in close agreement. This was true of the previous series.

(9) There appears to be no relation between the average weight of a kernel and the percentage of unsaponifiable matter in the oil (Table V). No relationship was shown in the previous series.

(10) There is no relation between the colour or the shape of the nuts and the percentages of unsaponifiable matter in the oil. This was also true of the previous series.

(11) *Comparison with the Samples from Nigeria* (see this

BULLETIN, 1930, **28**, 123; 1931, **29**, 407)[1].—As was the case with the previous series, on the whole the present Gold Coast samples are richer in oil and the oils contain less unsaponifiable matter than the Nigerian samples. The oil content of the Gold Coast kernels as received varies from 42·6 to 52·7 per cent., and mainly from 47·7 to 52·7 per cent.; the corresponding figures for the Nigerian samples are from 27·0 to 47·6 per cent. and mostly from 34·3 to 47·6 per cent. The unsaponifiable matter in the Gold Coast oils ranges from 3·6 to 8·3 per cent., with an average of 4·9; and in the Nigerian oils from 5·1 to 16·6 per cent., with an average of 8·8. It will be noticed that in both cases the Gold Coast results fall within much narrower limits than those for the Nigerian samples.

(12) A comparison of the present samples with those received from the Yendi Reserve in 1931 leads to the following observations:—

T Samples.—The kernels of the present series contain slightly more oil than those of the previous set, viz. 52·4 per cent. on the average against 50·4 expressed on the moisture-free material. The oils of the present series contain slightly less unsaponifiable matter than the oils of the earlier set, the average being 5·3 against 5·7 per cent.

Sample T5, the oil of which contained the highest amount of unsaponifiable matter in the previous set (8·9 per cent.), on the present occasion yielded an oil with only 4·4 per cent. of this constituent.

There are marked differences between the respective oil contents of the samples T5, T11, and T13 in the two series; also between the content of unsaponifiable matter in the oils of samples T5, T6, T9, T11, and T13. It should be noted that the nuts in the present sample T13 were much smaller than those of the previous sample, and that the present kernels contained less oil while the oil contained more unsaponifiable matter.

P Samples (Samples P4 and P5 of the 1931 series are left out of this comparison, as no 1935 samples from these trees were submitted).—The average oil contents of the kernels

[1] The nuts of the third series from Nigeria (*ibid*. 1933, **31**, 334) are not included in this comparison as they represented a special investigation and consisted of material collected at varying stages of maturity.

of the two series are very similar (52·8 against 53·2 per cent. for the previous set), but the oils from the present samples contain on the average less unsaponifiable matter (4·5 against 5·5 per cent.).

The oils from the present samples P3 and P6 contain less unsaponifiable matter than did the oils from the corresponding 1931 samples.

D Samples.—The oil content of the kernels of the present D samples is in each case very similar to that found in the earlier set. The nuts in the 1935 sample labelled D are, however, much smaller than those of the previous sample, and the oil from their kernels contains less unsaponifiable matter.

E Samples.—The two E samples gave similar results for oil content and amount of unsaponifiable matter.

R Samples.—The oil from the present R sample contained less unsaponifiable matter than that from the previous sample.

X Samples.—The oil from Sample X3 contained less unsaponifiable matter than that from the earlier sample from this tree. The oil from Sample X66 on the other hand contained more unsaponifiable matter than that of the previous sample, which had the least of all in the set. The kernels of the present Sample X37 contained more oil than those of the 1931 sample.

General Conclusions

The results of examination show that the oil content of nuts from a particular shea tree is liable to vary from year to year, as is also the amount of unsaponifiable matter in the oil. They also tend to support the provisional conclusion, drawn from the results of the examination at the Imperial Institute of the previous series of samples from the Yendi Reserve, and also of Nigerian samples, that the lower the oil content of the kernels the higher is the percentage of unsaponifiable matter in the oil.

ARTICLES

VANADIUM-BEARING MAGNETITE DEPOSITS OF DHALBUM AND MAYURBHANJ, BIHAR, INDIA

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During 1910-11, Mr. J. J. A. Page of the Geological Survey of India reported the occurrence of titaniferous magnetite in the neighbourhood of Pora and Kotwal Pahar in Dhalbum. This discovery was enshrined in an official report and escaped notice until 1929. In January of that year Dr. J. A. Dunn, while surveying the basic igneous rocks of Kotwal Pahar, collected further samples of this magnetite, but the specimens were not analysed at the time. In 1933 magnetite was collected further south around Dublabera. The first intimation that these titaniferous magnetites carried vanadium oxide was due to the Oriental Export and Import Co., who in 1933 sent specimens for analysis to Messrs. Briggs & Co., Calcutta (I and II); the Science College, Calcutta (III); and the Imperial Institute (IV). The analyses are given below :—

	(I)	(II)	(III)	(IV)*
TiO_2	18·0	13·6	28·70	25·01
Fe_2O_3	74·3	67·0	54·00	67·75
V_2O_5	7·6	4·9	8·80	7·90
Al_2O_3	—	3·50	—	—

* *Analysis by W. H. Bennett.*

Thanks to the good offices of the Imperial Institute, the record of their analysis was brought to the notice of the Minerals Adviser at India House, who passed on the information to the then Director of the Geological Survey of India.

In 1933-34 an investigation of the occurrences was carried out by the Geological Survey of India, and I am indebted to the Director for a copy of a report by Dr. J. A. Dunn and for permission to use the information in the preparation of this digest.

Distribution.—Magnetite has been found, in addition to the localities above mentioned, near the village of Lango;

south-west of Kudarsahi and south of Sindurpur. The mineral occurs in veins up to 1 ft. in thickness, but there is apparently nothing of sufficient size to be profitably worked. The vanadium content is variable and generally low.

The magnetite debris from a hillside one mile south of Sindurpur (20° 28′; 86° 15′) in Singhbhum was found on analysis by Dr. Dey to contain 71 per cent. iron and 1 per cent. nickel. An examination of polished sections of this ore indicates that only magnetite of a peculiar fibrous variety is present, and it is presumed that the nickel is in solid solution.

Magnetite is found associated with basic rocks in the Mayurbhanj State at the following localities: Kumharoubi (22° 17′; 86° 19′), Kaduani (22° 17′; 86° 21′), and north of Betjharan (22° 16′; 86° 19′). The deposit at Kumharoubi is easily the largest. The debris with magnetite boulders up to six feet in diameter covers the hill slopes in thick jungle. It is estimated that there are a million tons of ore in sight here. It must be emphasised that no exploratory work has been done on these deposits.

Geology and Petrology.—The magnetite occurs as small lenses and veins in the gabbro and its ultra-basic variants. These rocks are frequently altered, sometimes to epidiorite, sometimes to serpentine. In cases where the alteration has not been extensive the rocks appear to be basic gabbros, anorthosites, and peridotites.

The accessory minerals are apatite and iron ores. The latter are interstitial to the other minerals and appear to have been the latest minerals to form, while their deposition was accompanied by considerable alteration in the rock.

Analyses.—Both the vanadium and titanium contents of the ores are variable, and hence careful and detailed sampling will be necessary over each area before any opinion can be formed of the extent of the deposits and the average vanadium content. Analyses of several specimens of ore are given in the annexed table. The vanadium has been calculated as V_2O_3 instead of V_2O_5, as it is considered that the vanadium in the ores is more especially associated with the magnetite.

	Kumharoubi.	Ghose's Pit Dublabera.	Boulder Dublabera.	E. of Dublabera.	Chatterjee's Pit, Dublabera.	W. of Dublabera.	Balidungri.
	7	8	9	10	11	12	13
SiO_2 . .	0·57	9·76	1·27	2·03	8·48	1·00	2·44
TiO_2 . .	13·84	16·84	24·70	10·96	21·80	10·20	16·40
Al_2O_3 .	2·83	—	4·00	2·38	0·79	0·75	0·56
Fe_2O_3 .	72·17	42·88	34·95	52·69	40·24	60·68	66·03
FeO . .	8·07	24·22	28·67	26·70	23·63	20·01	11·93
Cr_2O_3 .	n.d.	n d.	0·19	n.d.	0·17	n.d.	0·13
MnO . .	0·14	0·52	0·29	0·22	0·33	0·13	0·13
CaO . .	trace	trace	0·13	trace	trace	0·05	trace
MgO . .	0·20	0·94	trace	0·31	0·78	0·59	0·34
H_2O- / H_2O+ .	1·33	2·45	0·69	1·66	1·73	2·79	1·55
P_2O_5 .	0·97	0·34	0·48	0·31	0·51	0·89	0·36
V_2O_3 .	0·59	2·20	4·84	2·20	2·01	1·92	0·59
Total .	100·71	100·15	100·21	99·46	100·47	99·01	100·46
Sp. Gr. .	4·685	4·166	4·67	4·807	3·816	4·386	4·291

None of the analyses made by the Geological Survey of India shows as high a vanadium content as the analyses given on this page; the necessity for careful sampling is thus further emphasized.

Mineralogy.—The specific gravity of the ores varies from 3·816 to 4·807, depending on the extent of replacement by haematite. Those ores which have been mainly altered to haematite are low in vanadium.

From a study of the ores by the reflecting microscope the following minerals have been identified: magnetite, vanado-magnetite, haematite, ilmenite, and rutile, as well as a little goethite and some lepidocrocite. Silicates are associated with goethite, and fine blebs of either spinel or silicates are occasionally arranged along both the octahedral and cubic directions in the magnetite.

Magnetite and ilmenite are closely intergrown, the ilmenite occupying the octahedral directions in the magnetite in all stages of fineness, from minute, almost sub-microscopic needles to quite coarse plates. Minute graphic intergrowths also occur. There are also large patches and irregular veins of ilmenite showing no such intergrowth. Rutile frequently takes the place of ilmenite, not only in the finer, but in the coarser structures. Haematite occurs in all the ores in varying amounts

and replaces the magnetite either partially or wholly. The formation of the haematite is attributed to weathering, but some of it is apparently original. Goethite, which is present in many of the ores, is considered to be entirely a weathering product. The blue-grey vanado-magnetite occupies the inter-ilmenite space completely and is naturally more abundant in the ores with higher vanadium content.

Origin.—The ores are considered to be genetically related to the gabbros and associated rocks. This relation is typical of such ores, but it is of interest to note that the magnetite veins in these rocks are in the neighbourhood of the haematite deposits—especially the largest deposit at Kumharoubi. The association of the two types of iron ore may be fortuitous; on the other hand it may be that there was a considerable absorption by the basic magma of ferruginous material, giving rise to an iron-rich magma.

In these basic rocks it is noticeable that iron-ore is the last mineral to crystallise out, in contrast with its early position in the normal crystallisation sequence, and it is suggested that a possible explanation is to be found in the reaction taking place between the late magmatic fluid and the earlier minerals, particularly titaniferous augite.

Utilisation of the Deposits.—Titaniferous ilmenites containing vanadium have been known from other parts of the world for many years, but have not been made use of so far, except in Russia, where it is reported that ores of a similar character have been recently used with success in the preparation of ferro-vanadium. The deposits in Dhalbhum and Mayurbhanj are certainly richer in vanadium than those already known elsewhere, but it is evident that much careful work in prospecting and sampling is necessary before the extent and average vanadium content can be determined. At present experiments are being carried out on methods of utilisation of the ores, and until these have been completed the future of the deposits must remain doubtful.

WORLD PRODUCTION OF MAGNESIUM

After a slow beginning, light magnesium alloys are rapidly finding widespread applications in machinery generally, and in road and air transport in particular. These applications, coupled with the growing importance of aircraft for military purposes, have focused serious attention on the question of magnesium production in all the more important countries. It may therefore be of interest to indicate briefly the steps which are being taken in various countries to meet the demand for the metal and its alloys. The industry on its present scale is comparatively recent, and the technique, not only of the production of the metal but also of its fabrication, is particularly intricate. It is not surprising, therefore, that much secrecy is observed with regard to processes, output, and progress generally. The United States is the only country for which official statistics of production are available.

It is noteworthy that the light alloys containing magnesium usually carry a very substantial proportion of the metal. Thus members of the well-known Elektron series of alloys contain from about 86 to about 96 per cent. of magnesium, the other constituents being mainly aluminium, zinc, and manganese. Similarly, Dowmetal is a magnesium-aluminium alloy containing over 90 per cent. of magnesium with small percentages of other metals. The saving in weight resulting from the use of magnesium alloys whenever possible may be considerable; for example, it is claimed that a given volume of metal weighing 6 lb. in Elektron would weigh 9·9 lb. in aluminium, 25·8 lb. in steel, and 28·2 lb. in brass ("Magnesium Alloys with special reference to Elektron," 2nd Ed., 1934, p. 57).

Nearly all of the magnesium of commerce is produced by the electrolysis of magnesium chloride, but the raw materials and methods used differ considerably. In one case a natural source of the salt is utilised, such as carnallite (a double chloride of magnesium and potassium) or salts from magnesian brine springs, whereas in other cases the magnesium chloride is prepared from magnesite. Estimates made by persons in close touch with the industry indicate that about two-thirds of the magnesium now being produced is obtained from magnesite, the remainder being from carnallite or brines. It seems

probable that in future, with a considerably increased consumption of magnesium, the chief raw material will be magnesite, but under special circumstances dolomite may assume some importance as a raw material.

United Kingdom.—The progress made in this country during recent years has been as follows: Murex, Ltd., in conjunction with Messrs. Johnson, Matthey & Co., who controlled certain fabricating patents, formed two companies, (*a*) Magnesium Metal and Alloys, Ltd., which confined its activities to the production of magnesium and magnesium alloys, and (*b*) Magnesium Castings and Products, Ltd., which concerned itself with the manufacture of magnesium products. Murex, Ltd., leased to Magnesium Metal and Alloys, Ltd., land at Rainham, Essex, on which the necessary plant and machinery were erected, and production commenced about April 1935.

At this stage a merger of some of the principal firms in the United Kingdom interested in magnesium metal was effected, resulting in the formation of Imperial Magnesium Corporation, Ltd., with a capital of £200,000, in which the participants were Magnesium Metal and Alloys, Ltd., the British Aluminium Co., Ltd., the Imperial Smelting Corporation, Ltd., and Imperial Chemical Industries, Ltd.

In addition to operating the plant at Rainham, the companies participating took over the experimental plant, working on the Calloy magnesium process at Avonmouth, which belonged to the Imperial Smelting Corporation, and it was anticipated that large-scale production would probably be effected in Scotland, where the British Aluminium Co. have their chief works.

In October 1936 the announcement was made that it had been found more convenient for each of the parties to this fusion to continue their research and investigations individually. The Rainham plant, patents, etc., which had been purchased from Magnesium Metals and Alloys, Ltd., by the Imperial Magnesium Corporation, have now reverted to Magnesium Metal and Alloys, Ltd., and Murex, Ltd., are purchasing the interest of Messrs. Johnson Matthey & Co., Ltd., in that company. Magnesium Metal and Alloys, Ltd., under the control of Murex, Ltd., are continuing the manufacture of magnesium at Rainham. The raw material used is magnesite. The

principal interest of Murex, Ltd., in Magnesium Castings and Products, Ltd., remains the same, and this company is making products from magnesium and magnesium alloys at Slough.

It is understood that the Imperial Magnesium Corporation, Ltd., is now controlled by the British Aluminium Co., Ltd., and the Imperial Smelting Corporation, and is interested in the establishment of magnesium production in this country by a new process.

Interesting information is available concerning the progress of Magnesium Elektron, a £400,000 company formed early this year by F. A. Hughes & Co. of London. Messrs. Hughes had for some time held the patents of the I.G. Farbenindustrie A.G., the German originators, in connection with magnesium production and fabrication, and for a number of years have fostered the very substantial and rapidly growing consumption of magnesium alloys in Great Britain. These patent rights and processes were acquired by Magnesium Elektron. A factory has been built at Clifton Junction, near Kearsley, the principal power station of the Lancashire Electric Power Co., and is expected to commence commercial production towards the end of 1936. Both magnesium and magnesium alloys are to be produced, and an initial output of 150 tons per month is expected, which, it is understood, is to be increased substantially in the near future. The process to be used is the electrolysis of fused magnesium chloride made from magnesite imported from Greece and other sources.

For some time past the demand for magnesium has outpaced the supply, but it is believed that the situation in this country will be considerably eased in the near future. The London price of magnesium ingots and sticks has for some time been about 1*s.* 6*d.* per lb.

Australia.—It was recently reported that the Australian Magnesite Co. was operating an experimental plant in Tasmania for making magnesium from magnesite.

United States of America.—The Dow Chemical Co., of Midland, Michigan, up to now has been the sole American producer of magnesium metal. The raw material used is magnesium chloride recovered from the company's salt wells near Midland. In 1934 the amount of new magnesium ingot and stick sold or used by this company was 4,249,838 lb. Most of this is consumed in the manufacture of magnesium

alloys. According to the president of the company, 2,000,000 lb. of Dowmetal were sold in Europe during the first six months of 1935, and this amount, coupled with a 40 per cent. increase in domestic sales, resulted in the disposal of more than twice as much Dowmetal during the half-year as in the preceding twelve months of 1934. However, the increasing demand for this light alloy did not give rise to a larger production of new magnesium ingot and stick for the whole of 1935, the final figure for which remained practically stationary at 4,241,218 lb.

The average price of magnesium metal for domestic consumption in the U.S. during 1934 is stated to have been 26 cents per lb., but in 1935 it had risen to 30 cents.

Research has been in progress with a view to making magnesium from magnesite in Washington and other western States. The Aluminum Co. of America, in conjunction with the I.G. Farbenindustrie, is understood to have had under consideration for some time the production of magnesium from this raw material.

Germany.—Commercial production of magnesium in Germany was begun a few years before the Great War, but for many years information concerning the processes employed and the production statistics was withheld. Even to-day it is stated there are few data upon which to estimate the volume of German production which, no doubt, is still the dominant factor in world supplies. As regards the international status of the magnesium industry, it was recently stated that Germany is technically and quantitatively leading in magnesium production. A year ago German production was estimated unofficially at 6,000 tons of the metal per annum. The I.G. Farbenindustrie A.G., with works at Bitterfeld, is the largest producer of the metal. Carnallite is used to some extent in the process, but it is reported that the principal source of magnesium now used in Germany is magnesite. On the other hand, the Wintershall A.G. has been occupied for some time with the production of magnesium from carnallite, and it is stated that their present output amounts to about 4 to 5 tons of the metal per day.

Austria.—Yet another process for the production of magnesium metal is used by the Austro-American Magnesite Co. at Radenthein, Austria, where dead-burned magnesite is the raw material.

The sintered magnesite is briquetted with the necessary amount of carbon, reduced, and vaporised in an electric arc resistance furnace with carbon electrodes, according to the reaction $MgO+C=Mg+CO$. The magnesium obtained is claimed to have the advantage of great purity (*Canad. Chem. Metall.*, 1936, **20**, 204).

Austria produces large quantities of magnesite, but only a very small proportion of this is used for the extraction of the metal.

Switzerland.—A plant was erected at Martigny in 1926 and has continued to operate up to the present time. Its output is stated to be about 250 tons per annum.

France.—Production of metallic magnesium in France commenced in 1915 as a war measure and was carried on, though probably in a rather small way, by the Pechiney concern (the Cie. Alais, Froges et Camargue), with works at Chedde (Haute-Savoie) and Saint-Auban (Hautes Alpes), and the Société d'Electrochimie, d'Electrométallurgie and Aciéries électriques d'Ugine, with works at Clavaux and at Jarrie (Isère). In 1930 these two concerns amalgamated their magnesium interests in the Compagnie Générale du Magnésium, and that company is using the I.G. German process employing magnesite as a source of magnesium chloride. Another firm producing the metal is the Société Bozel-Malétra, Paris. Early in 1935 the French Government, for national defence reasons, restricted the export of magnesium to those holding a licence. This restriction is still in force.

Russia.—In 1931 an experimental plant began operations in Leningrad under the supervision of specialists from the Cie. Alais, Froges et Camargue. Towards the end of 1934 the construction of a plant for extracting magnesium at Solikamsk in the Urals was announced. The raw material used is carnallite from the neighbouring potash deposits, the process being similar to that used by the Wintershall A.G. in Germany. Production commenced in April 1936, and it was stated that five electrolytic baths were in operation in May.

Italy.—The Montecatini concern obtained permission in August last to erect works for magnesium production.

Japan.—The annual consumption of magnesium in Japan has recently been estimated at 40 to 50 tons, about one-half of which is imported. The other half appears to be supplied

by the Nichiman Magnesium K.K., whose capacity is stated to be 150 tons per annum. The new Ube plant of the same company, now under construction, is to have a capacity of 350 tons a year. It is understood that there are large deposits of magnesite in Manchukuo, so that considerable expansion in Japanese magnesium production is possible. It was reported recently that the Kobe Steel Works are building a factory near Nagoya for the production of magnesium alloys. Small quantities of magnesium have been exported by Japan from time to time.

The Nippon Magnesite Mining Co., Ltd., with a capital of one million yen, was formed in Seoul in 1935 to extract magnesite for supply to the Nippon Magnesium K.K., of Konan, South Kankyo Province, Korea. According to recent reports, the Korean plant was completed by the end of 1935, but difficulties in operation were experienced, and production on a commercial scale does not yet appear to have been achieved.

INDUSTRIAL DIAMOND

To most people diamond is well known as the principal gemstone in commerce, but it is not so well known as an important mineral from the purely utilitarian point of view. Nevertheless, diamond is a mineral of growing industrial importance, and it is probable that in recent years at least 60 per cent. by weight of the world's diamond output has consisted of stones suitable only for industrial purposes. Taking the total diamond production for the year 1935 as being 7·3 million carats, this means that approximately 17 cwts. of industrial stones were produced.

The importance of diamond for industrial purposes depends almost entirely upon its hardness, which greatly exceeds that of any other substance. Its principal use therefore is for abrasive purposes, mainly in the form of tools of various kinds, including the crowns of core-drills, and also in the form of dust for lapping. The dust may also be bonded and moulded into abrasive wheels. Diamond is also employed for the reverse purpose, namely to withstand abrasion by other substances, notably in the form of draw-plates or dies used for

wire-drawing and as jets for oil-burning furnaces. The three varieties used for industrial purposes are known as carbonado, ballas and bort.

Carbonado, known in the trade as " Carbon " or " Black diamond," comes only from the State of Bahia in Brazil. The stones are black or very dark in colour and exhibit no external crystalline form, being made up of aggregates of microscopic crystals.

Ballas is a rather rare form of diamond, each stone consisting of an aggregate of crystals radiating from the centre, the external form of the best stones being almost spherical. Ballas is obtained from Brazil and from the Jagersfontein and Premier mines in South Africa, but is so rare as to be of little or no industrial significance.

All other stones which, on account of their poor colour, texture, shape or size, are unsuitable for use in jewellery, are classed together as *bort* (boart, bortz, boort, bowr). In the trade, however, the term " bort " is very often used in a more restricted sense to mean only the most inferior grades of diamond which can be used for no other purpose than in the form of powder.

On account of its lack of cleavage carbonado is eminently suitable for use in the crowns of core drills used for penetrating exceptionally hard rock. The size of stones employed varies widely with the size of crown in which they are set and ranges from about 0·15 carats upwards, the average being about 2 to 4 carats. Large pieces are broken up and shaped into cuboidal form and graded according to hardness, texture and appearance. Specific gravity is often used as a guide to effective hardness, stones of sp. gr. 3·1 to 3·3 being regarded of high quality, those from 3·0 to 3·1 of good quality, those from 2·9 to 3·0 of medium quality, and those below 2·9 as inferior. Scratching with ballas is also adopted as a method of judging hardness.

Some researches recently carried out by C. E. Wooddell in the laboratories of the Carborundum Company at Niagara Falls, in which the resistance to abrasion of various natural and artificial substances was investigated, throw an interesting light on the hardness of various kinds of diamond in relation to one another and to other hard substances.[1] The method

[1] " Method of comparing the hardness of electric furnace products and natural abrasives," by C E. Wooddell *J. Electrochem. Soc*, 1935, **68**, 111-130.

adopted gives a measure of the resistance to abrasion by grinding on a lap, and it was found that considerable variation exists in different kinds of diamond. South American brown bort was found to be consistently harder than other types, with South American ballas a close rival, while carbonado was distinctly less able to withstand abrasion. Next to diamond the hardest substance known is boron carbide, but there is a very large gap between this and the softest form of diamond.

Mohs's scale of hardness is of little use as a measure of the relative hardness of these very hard substances, and Wooddell has produced a table based on his abrading method from which an idea of the quantitative values of hardness of these may be obtained. It is calculated on the basis of quartz and corundum being 7 and 9 as in Mohs's scale, and runs as follows :—

South American brown bort	42·4
South American ballas	42·0
Belgian Congo yellow diamond	41·0
Belgian Congo clear white diamond	40·7
Belgian Congo grey opaque diamond	38·7
South American carbonado	36·4
Boron carbide	19·7
Black silicon carbide	14·0
Green silicon carbide	13·4
Tungsten carbide (13 per cent. cobalt)	12·0
Fused alumina (3·14 per cent. TiO_2)	11·0
Fused alumina "A"	10·0
African crystal corundum	9·0
Rock crystal (quartz)	7·0

As a result of the increased activity in diamond drilling in many parts of the world some years ago the demand for carbonado increased and the price rose to about £35 per carat in 1930. In consequence of this certain drillers began to experiment with crowns set with large numbers of small bort stones or with a mixture of bort and carbonado. The experiments were successful, and during the last few years there has been a largely increased demand for bort for this purpose with corresponding decrease in demand for and in the price of carbonado. The use of bort, costing about 10s. per carat, has reduced the cost of drilling on the Rand goldmines by at least 10s. per foot. Carbonado is now used only where broken

ground or chert-impregnated formations are to be pierced, and the price has dropped to about £8 per carat.

It has been estimated that of the industrial stones consumed, the majority (some 40 per cent.) are employed in the truing of abrasive wheels made of natural or artificial corundum, emery, silicon carbide or other hard abrasive substances bonded with shellac, bakelite, rubber, etc., which are being used to an increasing extent by the motor and other engineering trades for precision grinding. These wheels, in use, tend to lose their circular shape and to become dulled by small particles of metal on the surface. The use of a diamond-tipped tool is the only satisfactory means of turning up a fresh, true surface, and such tools are being employed in ever-increasing quantities. Diamond-pointed tools are being used to an increasing extent for the accurate machining of many non-ferrous metals and alloys, as well as of ebonite and synthetic resins such as bakelite, and in the motor manufacturing industry for the machining of big-end bearings and aluminium alloy pistons. The durability of the points of these tools permits of much saving of time, as they enable repetition work to be carried out for long periods without re-setting the machine. The technique of manufacture of diamond-set tools is rapidly advancing.

Diamond dies are widely used in wire-drawing, especially for very fine wires, and this use probably accounts for about 20 per cent. of the consumption. For this purpose cleavage plates or flat stones are mainly employed, the holes being drilled by fine diamond points and afterwards brought to the required diameter and polished by means of steel needles fed with diamond dust; a very slow process. The plate is cast into a steel slug and then mounted in a casing of brass on Monel metal. Up to 400 tons of copper wire can be drawn through a single die without variation in gauge, and for tungsten wire required for lamp filaments the hole may be as small as 0·0015 mm. diameter. For coarser dies the diamond has a serious competitor in hard metallic alloys.

The cutting of stone in quarries and stonemasons' yards is often accomplished by means of bonded abrasive wheels of large diameter and thin section, but may be more quickly done with steel circular saws carrying diamonds around the periphery. A large saw of this type, seven feet in diameter,

which would have more than a thousand diamonds embedded in its edge, has a life of some 2,500 sawing hours before the stones need re-setting.

One of the oldest uses of diamond is as an abrasive in the form of powder for lapping purposes. Gem diamond can only be cut and polished by this means, and the various hard substances such as tungsten carbide and alloy steels used for machine tools are also ground on cast-iron laps impregnated with diamond dust. From time to time attempts have been made to produce wheels and laps, the cutting faces of which were composed of diamond powder embedded in some bonding medium, usually synthetic resin. These have not been wholly successful, but a much superior product has lately been perfected and will shortly be manufactured commercially. The cutting surface of the new type consists of diamond powder embedded in a steel bond, and the abrasive diamond grains are so firmly held that wheels surfaced with this product are capable of cutting at approximately twice the speed of those fed with loose powder. It seems likely that these new products will provide a use for a large amount of bort suitable only for crushing, of which at present the supply exceeds the demand.

In oil-fired furnaces, the fuel-oil is atomised before ignition by being forced through small jets which are usually made of hard metal. In use the orifices tend to become enlarged by the passage of minute fragments of grit or by the corrosive action of acid in the oil, and this gives rise to increased fuel consumption. Several makers of such furnaces are now supplying diamond jets, which are similar to diamond dies, as these are unaffected by grit or acid.

The use of diamond in glaziers' tools is well known. For this purpose small dodecahedral crystals are employed weighing from 10 to 80 to the carat, the stones being set so that the cut is made by one of the edges.

Sharp fragments of diamond are employed for drilling small holes in gemstones, glass, watch bearings, etc., and in certain types of engraving. The points used in gramophone recording apparatus are also made of diamond.

Supplies of industrial diamond come on to the market through three main channels; (1) The Diamond Development Company, Ltd., and its associates, whose business is not only to trade in industrial stones but to develop new uses for them;

(2) diamond cutters and dealers who dispose of those stones which they find among their purchases to be unsuitable for gem purposes, and (3) the Brazilian producers.

The Union of South Africa has long been the principal producer of diamond for gem purposes, but owing to the suspension of work at the kimberlite mines the quantity of industrial diamond produced there has for several years past been greatly reduced. On the other hand, the greatly increased diamond output of the Belgian Congo and Angola together with that of Brazil, consists largely of stones which are unsuitable for jewellery and can only be employed industrially, and a proportion of the stones from West Africa and Borneo are also of industrial grade. One or two of the South African mines which produce high-grade gem-quality stones have recently begun working again, and these will to some extent increase the amount of industrial diamond on the market, but if the Premier mine were to reopen a very much larger quantity would become available, since the bulk of the produce of this mine has hitherto consisted of low-grade stones.

It is interesting to note that whereas gem diamond is mainly preserved, industrial diamond is consumed.

NOTES

The Exhibition Galleries.—Since the last number of this BULLETIN was issued a new cotton exhibit has been arranged in the Indian Court with the aid of the Lancashire Indian Cotton Committee. This exhibit illustrates the great variety of Indian cottons and the part played by some of them in the United Kingdom. Starting with a specimen of a cotton plant bearing cotton bolls, and a collection of representative Indian cotton staples, the exhibit goes on to illustrate stages in the spinning of yarn in Lancashire mills from each of three distinct types of Indian staple—short, medium, and long. To the right of the exhibit is shown a collection of beautiful cotton fabrics woven in Lancashire from these yarns.

A corner bench of Burma teak has been placed for the seating of visitors in the timber section of the Indian Court. This exhibit was presented by the Castles' Shipbreaking Co., Ltd. A set of seven elephant models in Burma teak, graduated in size, presented by Mr. France, of Messrs. Steel Bros., has also been added to the Indian timber exhibits.

To the Sudan Court has been added an exhibit received

from the Director of Economics and Trade illustrating the local manufacture of blanks and buttons from dom palm nuts; also a series of photographs illustrating the manufacture of salt at Port Sudan, prepared from negatives loaned by the Controller, Sudan Government Office.

To the Northern Rhodesia Court has been added a series of photographs of drawings of buildings in Lusaka, the new capital, received from the Chief Secretary to the Government.

In the East African Court has been arranged a series of photographs, received from the Chief Secretary to the Government of Nyasaland, illustrating a tour through the southern part of the Colony from Lake Nyasa to the Zoa Falls. Imperial Chemical Industries, Ltd., have furnished to the Court a showcase and exhibit to illustrate Lake Magadi troona and manufactured products derived therefrom, comprising specimens of sodium carbonate, bicarbonate of soda, Magadi cleanser, Magadi bath salts and crude and refined salt, all manufactured at the lake works.

In the newly-organised South African Court a diorama, designed and constructed in the Imperial Institute studio, has been installed to illustrate the wool industry of the Karroo. This is reproduced in Plate V.

The descriptive label attached to this exhibit reads as follows:—

A Karroo Sheep Ranch

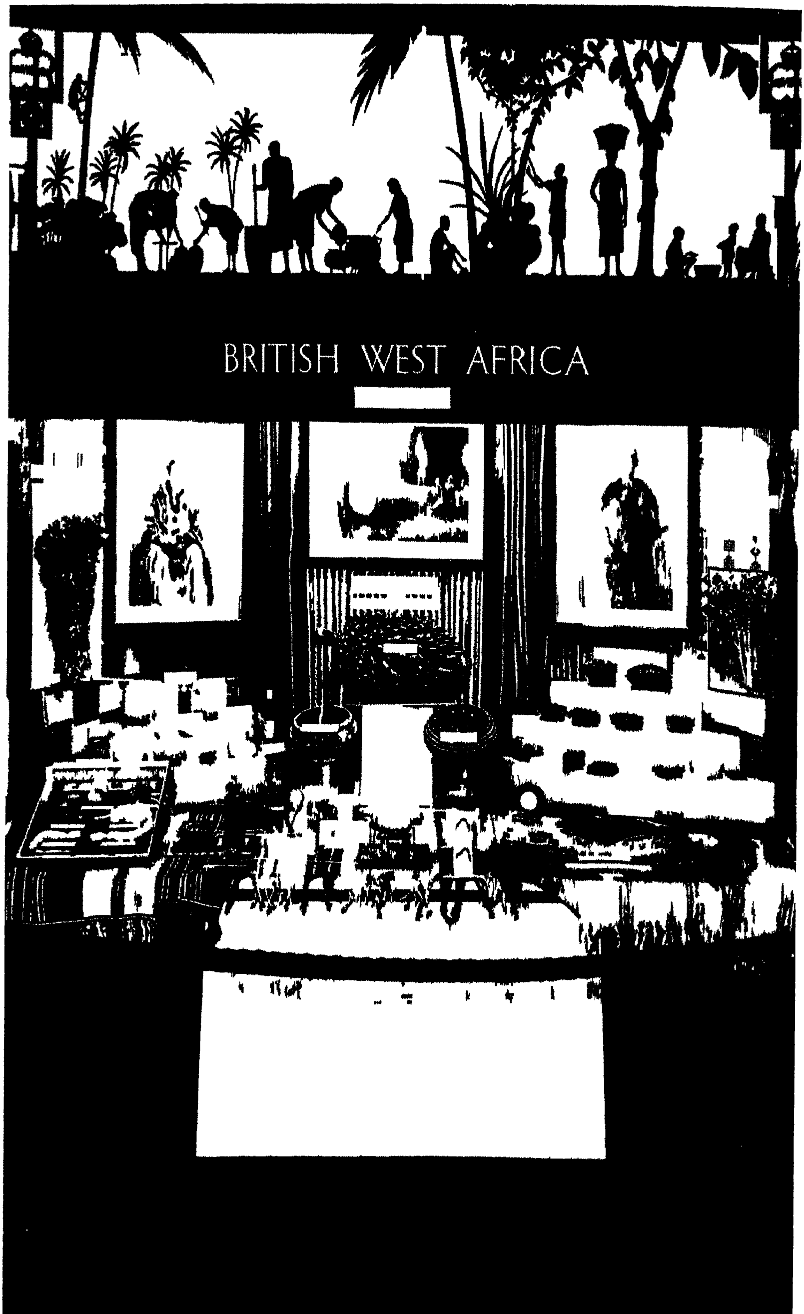
"South Africa is essentially a pastoral country and large areas are eminently suited for the raising of sheep and production of fine Merino wool. Among the best of these areas is the Karroo, those great plains, 2,000-4,000 feet above sea-level, which spread for over 100,000 square miles in the centre of the Cape of Good Hope, and extend north-east towards the Orange Free State. Though semi-arid in character, these plains produce a pasturage of somewhat sparse but highly nutritive shrubs, well relished by sheep, and here are situated some of the most extensive and most prosperous sheep ranches in South Africa.

"This diorama shows a typical scene on such a ranch, and well illustrates the flat character of this huge region and the manner in which it is broken here and there by the rugged heights of groups of kopjes.

"In the middle distance (to the right) is seen the sheep farmer's homestead and near it one of the semi-artificial ponds used for watering his flocks. Nearer to the spectator are groups of ranging Merinos which have been rounded up and are peacefully grazing, awaiting their turn to be shorn. Nearer still, sheep are being drafted into the shearing pens, where some may be seen undergoing the shearing process and others which have just emerged from the ordeal.

PLATE V

A Sheep Ranch in The Karroo, South Africa.
Reproduced from a Diorama in the Exhibition Galleries of the Imperial Institute.



[illegible] at the Colonial Empire Exhibition
The British West African Stand arranged by the Imperial Institute

"In the pen, to the right of the diorama, are some fine stud rams which, except at breeding time, are segregated from the main flock.

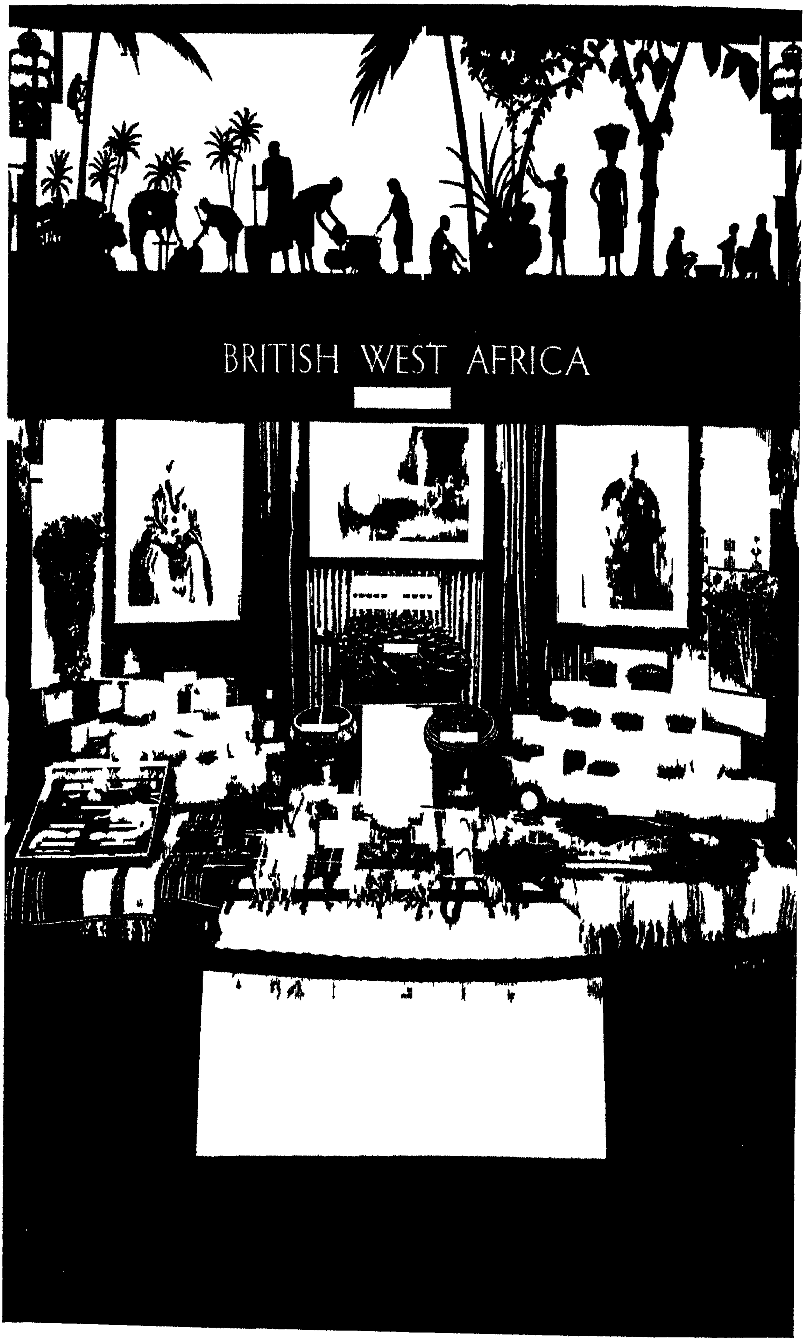
"In the middle distance, to the left, a typical bullock waggon is wending its way to the railhead, with a load of bales of wool for despatch to some South African or overseas market."

To the New Zealand Court has been added a new exhibit illustrating the utilisation of phormium fibre (New Zealand hemp) in the manufacture of rope, cord, and twine. This exhibit is arranged to tell a story under the caption "Strand by Strand." A series of photographs on one side of the show-case illustrates the cutting of the phormium leaf and the preparation therefrom of the fibre for export. By means of guide lines and arrows the photographs are connected with exhibits on the other side of the showcase which illustrate how the manufacturer in this country uses the fibre for the fabrication of ropes and twine. These latter exhibits, supplied by Messrs. Wright's Ropes, Ltd., of Birmingham, comprise specimens of the material at different stages of treatment, and photographs of the machines concerned in the various processes of hackling, drawing, spinning, stranding, and laying. A representative range of finished goods completes the story. Associated with this exhibit is a Maori cloak of phormium fibre which was brought to this country by Captain Cook. This serves to show how the fibre was used in New Zealand before the advent of the European in the country. In contrast with this is a modern wool-pack, made in New Zealand, and illustrating an important present-day local use for the material.

Through the courtesy of Mr. Harper Cory, F.C.G.S., and with the co-operation of the National Parks Branch of the Department of the Interior, Ottawa, a special exhibition of photographs depicting the scenery and wild life in the National Parks of Canada was staged in the Exhibition Pavilion. The Exhibition was opened by the High Commissioner for Canada on September 29 and remained on view until the end of October. These beautiful photographs revealed, in a remarkably graphic fashion, the multitudinous attractions of these wonderful holiday resorts "where the ill may be restored, and the well fortified and inspired by the sunshine, the fresh air, the beauty and all the other healing, ennobling and inspiring agencies of Nature and Nature's beauty."

The exhibition staff of the Institute were responsible for the arrangement of the West African stand at the "Peeps at the Colonial Empire" Exhibition held at the Charing Cross Underground Station in October (see below).

"Peeps at the Colonial Empire" Exhibition.—With a view to making the Colonial Empire better known to the general



[illegible] AT THE COLONIAL EMPIRE EXHIBITION
THE BRITISH WEST AFRICAN STAND ARRANGED BY THE IMPERIAL INS

"In the pen, to the right of the diorama, are some fine stud rams which, except at breeding time, are segregated from the main flock.

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"Peeps at the Colonial Empire" Exhibition.—With a view to making the Colonial Empire better known to the general

public an Exhibition illustrating the principal resources of the various countries was held recently at the Charing Cross Underground Station. The Exhibition was organised by a Committee consisting of the official London representatives of the Colonies concerned, and the layout and designs for stands and decorations were prepared by the Exhibition Staff of the Department of Overseas Trade in a most appropriate and effective manner.

The Exhibition was opened on October 9 by the Rt. Hon. the Earl De La Warr, Under-Secretary of State for the Colonies. In asking Lord De La Warr to open the Exhibition Sir Harry Lindsay, Director of the Imperial Institute and Chairman of the Committee of Management, spoke as follows:

"Ladies and Gentlemen,

"On behalf of the Committee of Management which has organised this Colonial Empire Exhibition, it is my great privilege and pleasure to welcome to-day the Rt. Hon. the Earl De La Warr, Parliamentary Under-Secretary of State for the Colonies. It would be presumption on my part to 'introduce' Lord De La Warr to you, for his keen interest in colonial matters is well known to all, from long before he took up his present post. I myself, and other members of the Empire Marketing Board, had personal experience of his wise direction and guidance during the happy heyday of the Board. It is a great pleasure to welcome him to-day.

"Before I call on Lord De La Warr formally to declare this Exhibition open, may I explain very briefly its inception and purpose? It owes its origin to the foresight of Major Simnett, the able and enterprising editor of the *Crown Colonist*. At Major Simnett's suggestion a Committee was formed, of which I have the honour to be Chairman, comprising the official representatives of East Africa, The British West Indies, Ceylon, Malaya, Cyprus and Malta, while the Imperial Institute represented the interests of British West Africa.

"Our object has been to make the Colonial Empire better known to the general public, and the title of the Exhibition has been aptly chosen as 'Peeps at the Colonial Empire,' for we attempt to portray here a series of 'stories' of the life, scenery and industries of the Colonies. There has not been space enough to show inside more than a few of the major Colonies or groups of Colonies, but you will find the whole list on this wall, and a most imposing list it is. Within, behind the Enquiry Office, will be found an instructive map, prepared by the *Crown Colonist*, showing the whole Empire, with the Colonies, Protectorates and Mandated Territories in special prominence.

"We think and hope you will all agree that this is a most attractive Exhibition. For the design and construction our grateful thanks are due to Captain Graham and Mr. Pratt, of the D.O.T., whose experience of exhibition work of the United Kingdom Government is of long standing and covers, for example, the long series of British Industries Fairs. We are also most grateful to the London Passenger Transport Board for having so generously placed this space at our disposal and for having given us every facility for carrying out the work of construction and decoration.

"With this introduction I have the honour to ask Lord De La Warr if he will kindly declare the Exhibition formally open."

In declaring the Exhibition open Lord De La Warr said:—

"It gives me great pleasure to come here to-day to open this Exhibition, on behalf of the Secretary of State, and to make my first public speech as Under-Secretary for the Colonies.

"First of all I have a message from the Secretary of State, Mr. Ormsby-Gore. He has asked me to express his best wishes for the success of the Exhibition. He hopes that it may be the means of bringing many people to a realisation of the vastness and of the greatness of the British Colonial Empire.

"Secondly, he has asked me to express his congratulations and thanks to the gentlemen who have been responsible for arranging this Exhibition; to Sir Harry Lindsay, Director of the Imperial Institute, and to Major Simnett, Editor of the *Crown Colonist*, who have acted as Chairman and Secretary of the Exhibition Committee; to the representatives of the various Colonial agencies —the East African Dependencies Office, Malaya House, Ceylon House, the Cyprus and Malta Government agencies, and the West India Committee; to the Department of Overseas Trade, and to the London Passenger Transport Board for the facilities so generously provided.

"The British Colonial Empire covers 2 million square miles and contains a population of 60 million people. For this Empire and for the welfare of all its inhabitants, the British people, through Parliament, are responsible. Yet there is still a great deal of ignorance about the Colonies. To try and explain briefly what the Colonial Empire is, and how it differs from the Dominions, a leaflet has been prepared, accompanied by a reproduction of the map which faces me, which will be available for distribution to those interested. I hope that a great many people will take the leaflet home and study it, and that their interest will be quickened to visit that great museum of Empire, the Imperial Institute at South Kensington.

"This is not the occasion for a profound speech on Colonial Policy, but there is one thing that I should like to say about our general attitude to the whole Colonial question. We regard our Colonies as a Trust, held by us for the advantage of the native populations. They are not our property, to use as we like. Just as we impose rules upon the Public Trustee in this country, so we impose rules on our own conduct as public trustee for the vast countries of our Empire in Africa, in Asia, in Central America, in the Mediterranean and in the South Seas. We must do all we can to help them to make the best of themselves and of their countries. I am not speaking merely of plans for the future. Much has already been done for health, education and economic progress in the Colonies. Our programme is being pressed forward energetically at this moment. For instance, the interest which has recently been focussed upon nutrition in this country has extended into the Colonial sphere, and the Secretary of State, in co-operation with Colonial Governments, is taking measures which will, it is hoped, ultimately effect an improvement in the standard of nutrition of all the peoples in our care.

"This Exhibition is a sign that interest in the Colonial Empire is increasing. I wish it every success. I hope that, by means of displays such as this, by means of films and books, and through the Press, the entire population of this country may be made thoroughly conscious of, and proud of, our opportunities, our aims, and our achievements."

The Exhibition remained open until the end of October, and was the source of much interest to the general public. In the opinion of the London Passenger Transport authorities it was one of the most successful and best attended of the many short-period exhibitions ever held in the Station Exhibition Hall.

The following description of the layout of the Exhibition may be of interest to those concerned in the organisation of similar exhibitions overseas.

The fittings comprised a dividing screen to separate the Exhibition from the Station area. This was a plain structure of ivory white with the title of the Exhibition in gold lettering across the top. In the centre, through a grille, was seen an illuminated globe with the Empire countries in red. The grille was flanked on each side with panels bearing in red lettering the names of all the British Colonies, Protectorates, and Mandated Territories in alphabetical order, surmounted by the Crown and Royal Monogram in gold.

On the reverse side of this screen was the " Crown Colonist " map of the Empire, above a counter for the display of free literature. A gangway separated the counter from the Exhibition stand which consisted of seven bays forming a semi-circle, a bay being devoted to each country or group of countries participating in the Exhibition.

Above each bay was a fretted panel with an appropriate design in black against an illuminated blue background. The seven panels formed a frieze and a most striking and effective piece of decoration.

A photograph of the West African stand is shown in Plate VI.

Colonial Visitors.—The following is a list of officers on home leave from the Colonies who have visited the Institute during the past quarter :—

AUGUST

A. BEAN, Inspector of Mines, Federated Malay States.
A. E. CARTMELL, Sudan Government Railways, The Anglo-Egyptian Sudan.
E. H. DUCKWORTH, Inspector of Education, Nigeria.
W. C. ROY, Agricultural Officer, Virgin Islands, Leeward Islands.
Sir SHENTON THOMAS, K C.M.G., O.B.E., Governor, Straits Settlements, and High Commissioner, Federated Malay States.

SEPTEMBER

R. S. CHAMPION, Financial Adviser, Trans-Jordan.
A. J. W. HORNBY, M.B.E., Assistant Director of Agriculture and Chief Chemist, Nyasaland.
S. G. C. KNIBBS, Commissioner of Lands and Crown Surveyor, British Solomon Islands.
Dr. A. E. S. McINTOSH, Botanist, Barbados.
R. S. MARTINEZ, Superintendent of Agriculture, Jamaica.
Sir HENRY MOORE, K.C.M.G., Governor, Sierra Leone.
G. D. OWEN, C.M.G., Colonial Secretary, Barbados.
B. T. STEEMSON, Agricultural Officer, Gold Coast.

OCTOBER

Dr. G. BRYCE, Assistant Director of Agriculture, Nigeria.
P. C. CHAMBERS, Agricultural Officer, Kenya.
N. CRAIG, Biochemist, Sugar Cane Research, Mauritius.
Dr. T. H. DALRYMPLE, Medical Officer, The Gambia.
N. R. FUGGLES-COUCHMAN, District Agricultural Officer, Tanganyika.
K. L. HALL, Chief Secretary to Government, Nyasaland.
A. D. HUSBAND, Chief Chemist, Department of Agriculture, Southern Rhodesia.
Dr. F. T. INGHAM, Mining Geologist, Geological Survey, Federated Malay States.
G. C. KITCHING, O.B.E., Government Secretary, St. Helena.
J. P. A. MORRIS, Director of Veterinary Services, Northern Rhodesia.
J. MULLINS, O.B.E., Commissioner of Lands and Mines, British Guiana.
J. PIRIE, Agricultural Superintendent, The Gambia.
J. D. POLLETT, Assistant Geologist, Sierra Leone.
Dr. S. J. Saint, Assistant Director of Agriculture and Agricultural Chemist, Barbados.
C. SMITH, Conservator of Forests, Johore.
Sir WILFRID T. SOUTHORN, K.B.E., C.M.G., Governor, The Gambia.

All Dominion and Colonial officers who may be visiting London are invited to come to the Institute to see our Galleries or to discuss scientific and technical problems in which they are interested.

Derris Root.—The use of derris root as an insecticide has made great strides in recent years. At present the bulk of the commercial supplies comes from Malaya, Borneo, and neighbouring countries, but the possibilities of the crop are now under consideration in other tropical countries. The problem at once arises as to the best kind of derris to introduce for cultivation in a new country. The question is not easy to answer as not only do the different species vary in composition as regards their constituents of insecticidal value, but there appears to be some variation in this respect within the species itself. Difficulties also arise from the fact that the authorities are not yet in complete agreement as to the most efficient method of evaluating the roots with reference to insecticidal activity.

The Director of Agriculture, Tanganyika Territory, recently consulted the Imperial Institute as to the method of evaluating the roots and the species of derris best suited for cultivation in the Territory, and the opportunity was taken of obtaining the opinion of different authorities in this country on the subject. Dr. F. Tattersfield, of the Rothamsted Experimental Station, was consulted with special reference to the chemical and biological aspects of the problem, and a leading firm of insecticide manufacturers was approached in order to obtain reliable opinion as to commercial requirements. Advantage was also taken of the presence in this country of Dr. R. R. Le G. Worsley, of the Agricultural Research Station, Amani, to discuss the subject with him and to obtain further particulars

of the present position of derris in East Africa. A memorandum summarising the position as regards the evaluation of derris and the species to be recommended for cultivation, so far as can be stated at the present time, was prepared at the Imperial Institute and submitted to Mr. F. A. Stockdale, Agricultural Adviser to the Colonial Office, who kindly suggested certain additions, especially in relation to the control of planting material to be introduced into the country. The memorandum as finally furnished to the Director of Agriculture, Tanganyika, is printed below.

A Note on the Evaluation of Derris Root as an Insecticide and on the Species to be recommended for Planting

(1) *Evaluation.*—The question of the varying standards of evaluation of derris as an insecticide is one which at present remains unsettled on account of the difficulty of arriving at a satisfactory state of knowledge concerning the isolation and identification of the toxic constituents of derris root and the absolute and relative toxicities of these constituents as ascertained by biological tests. It is recognised that, primarily, the evaluation of an insecticide is a biological problem, but practical difficulties in applying this criterion emphasise the need for a reliable chemical method, readily applied; several such methods have been proposed, but at the present moment no particular method can be finally recommended owing to the difficulty of correlating the results with those obtained by biological tests. The technical problems involved in both fields of investigation are complex, but progress is being made towards their solution and valuable information is being accumulated by workers in Malaya, Java, Japan, East Africa, the United States, and, not least, in this country. There is, however, a fact of outstanding importance to the producer and to the buyer, viz., that species of derris, and different varieties of the same species, vary greatly in the toxic potency of the commercial material prepared from them.

It is definitely known that the insecticidal value of derris depends upon the quantity and character of the resinous "ether extractive matter" obtainable from the root. It would also appear that the ether extract is not entirely composed of toxic substances, so that "total ether extract" is not necessarily a direct measure of toxicity. Further, it is not at present clear whether the toxic portion of the ether extract exists in the root as one substance or as a number of toxic substances, but it is known that by current chemical methods there can be separated from the ether extract a crystalline toxic substance, rotenone, and also other toxic substances, which can be obtained in crystalline form, described as deguelin, tephrosin, toxicarol, etc., though it would now appear that

these last-mentioned substances may not occur as such in the extract but result from chemical changes involved in their preparation. At different times percentage contents of rotenone, ether extract, methoxyl, and dehydro-derivatives have each been advanced as chemical criteria of toxicity, and until recently the view was gaining ground that the dehydro-derivatives afforded the most satisfactory estimate of potency. This opinion, however, is now in doubt, and the question is best regarded as still an open one. There would seem to be support for the view that the origin of the toxic constituents of derris is a substance acting as a " labile precursor " which gives rise under the conditions of varying chemical processes to the varying poisonous constituents described by investigators, the most objective and best known of these constituents being rotenone. This conception would seem to provide an explanation of the fact that samples of derris found to yield no " rotenone " from the ether extract have been found to be markedly toxic, while, on the other hand, practical experience shows that for the main bulk of derris put on the market the percentage of rotenone in the extract is a very valuable and probably still the best index of the potency of the root.

In recent years attention has been given to the varying optical properties of the different constituents of the resin complex derived from derris and the value of the variations as a means of estimating the proportion of toxic constituents in the resin ; developments in this direction will be watched with interest.

The importance attached by Roark in the United States to the toxic value of rotenone led to the adoption of a commercial standard based upon the percentage of rotenone, and this standard still holds the field in America ; in the United Kingdom the potency of the non-rotenone portion of the ether extract as well as the rotenone was recognised, and the standard adopted has, therefore, been based on ether extract which includes the rotenone. Fuller knowledge of the subject, however, has led to the recognition in each of these markets of both criteria of toxic value, and attention, therefore, is being given to " ether extract " as well as to rotenone in the United States of America, while in this country the importance of the rotenone content is fully recognised, and one leading firm of buyers purchase their supplies of root on the basis of rotenone *plus* ether extract contents. Opinion in the Dutch East Indies attaches special importance to the rotenone content in the valuation of the root.

A recognised point of difficulty is that although the percentage of ether extract can be readily ascertained, widely different results as regards the percentage of rotenone present may be obtained by different workers with the same sample

of root. The adoption of a uniform method of analysis of derris is a great desideratum, but further investigation is essential before a satisfactory method is likely to be evolved and generally accepted. A paper discussing this matter will shortly be published by the Malayan workers on the subject.[1]

(2) *Species for Planting.*—The position as regards the type of derris to be recommended for cultivation, which question depends upon the requirements of the market and consumers, is clearer. The criteria upon which the root is purchased are, as stated above, (*a*) rotenone content, and/or (*b*) total ether extract. The percentage of rotenone present in a sample of root is not necessarily a measure of the full toxicity of the material, but since rotenone is known to have a high toxic value its presence in satisfactory proportions is a guarantee of potency, and this is fully recognised by the trade. Consequently, at present, derris root with higher percentages of rotenone has a higher market value than root with lower percentages of rotenone, and, if it is coupled with a high ether extract, so much the better; but manufacturers, when it suits their purposes, are willing to purchase (at appropriate prices) roots with low percentage of rotenone, or even to purchase on a basis of ether extract alone, using such latter roots to blend (mix) with roots of comparatively high percentage of rotenone content to manufacture a product having a medium (but effectively toxic) percentage of rotenone, on which percentage the product is usually sold.

Normally, therefore, the primary trade requirement is a derris root having a satisfactory percentage of rotenone. At the present time it is known that *Derris elliptica*, in selected varieties, possesses a rotenone content well in advance of other species of derris (e.g. *D. malaccensis*) and the scientific selection work on derris now being carried out in Malaya, Java, and at Amani, is concentrating on this species; already, selected strains of *D. elliptica* having 9 per cent., 10 per cent. and even more of rotenone have been detected and are being propagated for commercial cultivation. It must be recollected, however, that the bulk of the derris root at present marketed is of comparatively low rotenone content.

So far as can be seen, planters in Tanganyika Territory would therefore be well advised to confine their attention to selected varieties of *D. elliptica* having as high a rotenone content as possible in order to take advantage of the superiority believed in some quarters to attach to the presence of rotenone. Their obvious source of planting material is the East African Agricultural Research Station at Amani where a variety of

[1] A paper by Georgi and Gunn, entitled *Notes on the Preparation of Derris Root for Export together with a suggested Method for Evaluation*, has now been published in the *Malayan Agricultural Journal* for October 1936.

D. elliptica stated to have a rotenone content up to 8-10 per cent. is being cultivated, and planters should be recommended to obtain their supplies from this convenient centre. If available or early prospective supplies of cuttings at Amani are not sufficient for the demand, and it is felt that introductions should be made, it is important that only material of high quality (rotenone content) should be secured from Malaya and Java. All proposed introductions should be made with the approval of the Director of Amani and should pass through the Quarantine Station which has been established there. Departments of Agriculture in giving permits for introduction should take advantage of the services which Amani can render in this matter. The risk attaching to obtaining cuttings from another country should be recognised.

Not only must disease questions receive consideration; it is also important to recognise that introductions may grow well and yield high quality material in their new home, but there is a chance to the contrary; the possible influence of manuring must also be taken into account. The advantages of the Amani material, which is presumably adapted to general local conditions, are obvious.

It is important to note that high quality varieties of *D. elliptica* are being extensively planted in Malaya and Java, and if growers in Tanganyika Territory are to be able to compete successfully in the market it is essential that their product should be of at least equal quality. The Imperial Institute has been informed that the amount of *D. elliptica* root likely to be marketed in two or three years' time from Malaya and Java will be very considerable and, since newly-planted derris in Tanganyika would be marketed at about the same time, it is essential that the Tanganyika root should be able to compete with the admittedly high-quality product from these eastern countries. If the root shipped from Tanganyika is of definitely inferior quality it will obtain lower prices. It may be that selected strains of *D. malaccensis* will prove of great value for many purposes but at present it seems undesirable that this species, which usually contains at best up to 3 per cent. rotenone and 25-30 per cent. ether extract, should be planted in Tanganyika. In experiments carried out in Ceylon in 1934, figures were obtained which seemed to indicate that *D. malaccensis* grown at Peradeniya gave a higher yield of total ether extract per acre than *D. elliptica* (see this BULLETIN, 1935, **33**, 199-201). It might be thought from these results that the former species would be preferable to grow. The trade authorities consulted by the Imperial Institute, however, would not recommend planters to obtain from Ceylon cuttings of the *D. malaccensis* referred to in the experiments. The figures recorded in the results of

the experiments would appear to show that the *D. malaccensis* in question was somewhat below a "good" variety of that species as regards ether extract, while the variety of *D. elliptica* with which it is compared (to the detriment of that species) is one which is far below a "good" variety of *D. elliptica* in its total ether extract. The total moisture-free ether extract recorded as obtained from roots $24\frac{3}{4}$ months and 28 months old is 8·55 per cent. and 5·98 per cent. respectively, while a good selected strain of *D. elliptica* might be expected to yield, say, 25 per cent. ether extract including perhaps 9 to 12 per cent. of rotenone.

Further in these experiments it will be observed that the recorded yield of root per plant in both species was abnormally low, whilst no particulars are given regarding the number of plants grown per acre in each case; in considering any view that the erect-growing *D. malaccensis* can be grown closer together than the ground-creeping *D. elliptica* it should be remembered that at Amani and in Java this latter species is being trained upright on stakes which admits of the plants being grown as close together as *D. malaccensis*.

It is clear, however, that the yield of marketable root per plant is a factor of great importance in selecting a variety for cultivation since it would be possible for a variety of derris having a moderate toxic content but yielding a heavy crop of roots to be more valuable to the planter than a variety with high toxic content but yielding a small crop of roots. This of course is true as between the variations in both characters mentioned met with in different varieties of the same species as well as in different species. The situation, however, is complicated by the fact that root yield is influenced by varying circumstances, e.g., planting distance, method of cultivation, soil characters, manuring, time of harvesting, etc.; and certain of these factors (e.g., time of harvesting) are known also to affect the toxic content. This subject is dealt with in a paper on "Preliminary Selection Experiments with Derris," by Messrs. Georgi, Lambourn and Gunn (*Malayan Agricultural Journal*, August 1936). It would appear that the Singapore variety of *D. elliptica* has a high yield of marketable roots as well as of ether extract and rotenone. The importance of yield of marketable roots is no doubt recognised in Tanganyika in view of the system adopted at Amani of growing normally creeping *D. elliptica* on upright stakes.

As additional support for the opinion that planters of derris should pay special attention to the cultivation of the best species and varieties available to them may be mentioned the competition in the United States of cubé root (*Lonchocarpus nicou*) and other South American toxic plants yielding a high

percentage of rotenone. The use of these materials in America as insecticides is rapidly increasing, and they are also being imported into this country.

Storage of Native Foodstuffs in the Tropics.—The following notes regarding methods of storing the commoner native foodstuffs were compiled in connection with an enquiry received recently at the Imperial Institute from the Director of Agriculture, Tanganyika Territory, and are now published for general information.

Maize and other Cereals.—For the safe storage of maize in bulk it is essential that the grain be thoroughly dried in order to prevent heating and mould, and that the moisture content be less than 14 per cent. In addition, precautionary measures must be taken to discourage insect pests, of which the most destructive is the rice weevil (*Calandra oryzæ*). Grain containing more than 20 per cent. of moisture will not only begin to heat, but is particularly favourable for the development of weevils, the optimum moisture point for which is between 17 and 20 per cent. Weevils are unable to live in dry grain containing less than 8 per cent. of moisture, and are unable to carry on active life in the absence of air, and these conditions must be aimed at as far as possible in storing the grain.

Various methods of storing maize are used in tropical, sub-tropical, and other countries. The method adopted by the natives in various parts of Africa, of storing corn on the cob and in the unhusked condition, either in small, especially erected buildings on their farms, or on shelves or racks in their houses, or hung up in various ways, may be satisfactory for small quantities of maize to be kept for short periods, more especially in the case of the hard and flinty varieties, but such methods are not suitable for storing grain in bulk for any length of time.

On the Gold Coast maize has been successfully stored in airtight petrol or kerosene tins. Corn so stored showed no appreciable loss of weight and proved to be free from weevil attack after a period of eight months, whereas well-sheathed corn stored in a native barn showed a decrease of 25 per cent. in weight and was of less attractive appearance.

Grain in bulk is generally stored in tanks or buildings specially constructed for the purpose, such as silos, galvanised iron sheds, or elevators.

Three methods for ensuring the successful storage of maize in sealed air-tight tanks may be briefly described as follows: (*a*) The tank is rammed completely full of maize before sealing, the metabolic process going on in the grain being apparently sufficient to exhaust the remaining oxygen and to fill the tank

with carbon dioxide. (*b*) Lighting a candle in a nearly filled tank and then sealing; this exhausts the oxygen and fills the tank mainly with carbon dioxide. (*c*) Fumigation of the maize in the tank with carbon bisulphide or carbon dioxide gas and sealing down quickly. It is stated that maize can be successfully stored by these methods without danger of heating. It is important, of course, that the corn be thoroughly air-dry before being put into the tank, and also that the tank itself is dry; this can be achieved by lowering a can containing hot coals into it before putting in the maize.

Corrugated galvanised iron containers are the most efficient and economical type of tank for the storage of maize. Such tanks can be constructed in sections, the sides being riveted and soldered at the joints and the lower end of each section of the tank should overlap the section below in order to keep out moisture. The lower sections should also be of a stronger gauge than the upper in order to withstand the greater pressure. The tank itself should rest on a concrete or wooden platform and supports should be placed round it to hold it against the wind when empty. For filling the tank a scaffolding bearing a small platform is necessary; the opening at the top of the tank can be sealed by means of a flanged lid, the flange of which fits between two circular collars, the inner one of which is higher than the outer, into which space oil is filled, thus making the tank airtight. A lower opening is also desirable for fumigating purposes. If found necessary to fumigate maize for the prevention of weevil, 1½ to 3 lb. of carbon bisulphide for every 100 bushels of grain, according to tightness of packing of the grain may be used. This can be poured into saucers or on to cotton waste placed in dishes put on top of the grain to be treated. The tank should remain airtight for a period of twenty-four hours after which the fumes must be allowed to escape by openings at the top and bottom, care being observed not to smoke or place a light near the fumes. Fumigation with carbon bisulphide does not injure the grain for food, and the disagreeable odour passes off on exposure to the air.

In South Africa grain is usually stored in bulk or in sacks, either in tanks, rooms, lofts, or elevators, while for co-operative purposes large sheds made of galvanised iron are used in the corn-growing areas. In Rhodesia a simple and effective way of storing mealies is stated to be in a square brick building with a granite floor and a trap door at the top of one wall for pouring in the mealies; a hole 2 ft. long by 1 ft. high at the bottom of one wall, leads into a trough, which has a hinged door on the top which can be locked.

When sheds are used for the storage of maize in sacks they should be so constructed as to admit the maximum

amount of air and light. This is particularly necessary in humid climates. If weather conditions permit the sides may be constructed of thick mesh wire netting, while the roof should project sufficiently to prevent beating by the rain. Should weather conditions make wire-netting sides impracticable, walls having large doors and ample window space fitted with movable wire-netting frames should be provided. Cement, concrete, or tight wooden floors are desirable as they can be cleaned easily. When storing grain in sacks it is important to prevent them coming into contact with the floor. This can be achieved by stacking in rows, on poles, rafters or beams, running parallel with the shed, in such a way as to allow space for inspection, and circulation of air to ensure dry grain and prevent overheating.

Fumigation may be carried out in the shed by placing each sack on a tarpaulin and treating with 2 oz. of carbon bisulphide, the liquid being thrown on to each sack in order that it runs through on to the grain. The bags are then covered by folding over the tarpaulin and left for 72 hours.

When grain stored in bulk requires fumigation 5 pints of carbon bisulphide per 1,000 cu. ft. of air space, including the space occupied by the grain, should be distributed on the surface and at depths of 5 ft. Fumigation should not be carried out when the temperature is below 70° F.

In the United States of America seed-corn curing and storing houses are used for maize storing; these are so constructed as to provide free ventilation and artificial heat when necessary, also protection from insects and rodents, and weather damages. Such houses are built on high and narrow lines, having two or three stories as the warm air rises more effectively in such buildings. The air may be heated to a temperature of 109° F., though temperatures ranging from 80° to 100° are generally effective, and the heat should be maintained to keep the corn to a moisture content of 14 per cent. or less.

Rice and wheat require similar precautions as regards moisture and protection from weevil as maize, but the moisture content of the rice before storage should be lower, viz., 12 per cent. or less.

In India wheat has been successfully stored by putting it into open-mouthed receptacles and covering the grain with a layer of sand. A sheet of cloth, wood, or iron may be placed in between to prevent the grain becoming mixed with the sand.

Beans.—In storing beans for food, artificial heat may be used for drying; as in the case of maize, the seeds should be thoroughly cured to reduce moisture content, as undue moisture leads to moulds and heating may result. Good ventilation in

the store is essential, and providing the moisture is kept at a minimum, the temperature factor is not so important. The bean weevil, which is the chief pest of stored beans, begins life in the field and breeds in dry seeds, consequently treatment should be resorted to as soon as the seeds are ready for storage. Heat and fumigation are the best remedies. Weevil-infested seeds may be poured into boiling water which is drained off at once, followed by a thorough drying before storing. An alternative method is to heat the seeds to a temperature of 145° F. or higher. Fumigating with carbon bisulphide is one of the best methods of treating infested seeds. The seeds should be placed in an airtight room or tank and treated with 1 oz. of carbon bisulphide for every 100 lb. seed for 48 hours. When applied at a temperature of below 60° F. the amount of carbon bisulphide used should be increased. The liquid may be sprinkled over the surface of the pile without injury to the seeds. After treatment the seeds should be exposed so that the fumes will be liberated.

Ground-nuts.—These can be stored for long periods if kept in the undecorticated condition, but they soon deteriorate after shelling. When storing ground-nuts, precautions should be taken against rats and mice and the store should be well ventilated and dry. Ground-nuts are usually stored in sacks, or cribs, similar to those employed for the storage of corn.

Yams.—The most satisfactory manner of storing yams is by arranging them in layers, three or four deep on shelves, in well ventilated rooms. The tubers should be mature before harvesting, and care should be observed during lifting operations and storage to avoid damage by bruising. Bruised tubers are liable to fungoid attack and should be treated with Bordeaux mixture or slaked lime to prevent spread of infection. In the West Indies the yam scale is sometimes a serious pest as it continues breeding on stored roots and causes them to shrivel. In various parts of Africa the Dynastid Beetle (*Heteroligus claudius*) is one of the troublesome pests of the yam crop. Yams may also be stored in small heaps in well ventilated rooms protected from rats and mice, or in pits, though this method cannot be recommended unless the soil is thoroughly dry and likely to remain so. In West Africa the natives in certain areas store their yams in a specially constructed "yam house." These "buildings," which are of a temporary nature, are made from materials obtained in the locality and consist of a number of posts arranged a small distance apart in the form of a square or oblong on which the yams are tied; sometimes the "buildings" have a roof of light thatch or palm leaves to protect the yams from the sun, and if on a large scale, additional racks running down the centre.

Under all conditions of storage yams require regular inspection to remove diseased tubers, otherwise infection will spread rapidly, resulting in considerable loss.

Cassava.—Cassava tubers do not store well for any length of time after removal from the ground and exposure to the air. Cassava " chips," however, can be kept for a long period. The preparation of cassava chips consists of peeling and slicing the roots (or splitting and cutting into pieces a few inches long and an inch or less thick) followed by drying in the sun until very crisp. When the chips are required for use they may be pounded and sieved in order to separate the fibre from the flour.

Sweet Potato.—In storing the sweet potato similar precautions to those required for the storage of yams should be observed. The sweet potato has a thin delicate skin and is therefore particularly liable to injury, consequently, when lifting great care should be taken to avoid cutting or bruising which lead to decay. The loss from carefully handled sweet potatoes may amount to as much as one-sixth less than that from others less carefully handled. Though sweet potatoes may be left in the ground for varying periods after maturity, such practise is undesirable as sprouting and decay tend to take place. In Trinidad various methods of storage have been attempted experimentally. These consisted of storing in clamps or pits (with or without ventilation), and in layers of sand, in bags, and in a well-ventilated store, in heaps, piled on sacking, and on shelves in layers 3 or 4 in. deep. Of these methods the most satisfactory appears to be storage in pits (either ventilated or unventilated)—decay being almost negligible and loss due to shrinkage low. The tubers stored in bags showed less decay but considerable shrinkage. Decay was not marked in the case of the tubers stored in the heap, but the loss through shrinkage however was high.

In the United States of America considerable attention has been given to the question of storage of the sweet potato on account of the great losses occasioned by market gluts shortly after harvesting the crop. Specially built sweet potato storage houses built of wood, brick, hollow tile, cement, or stone are used for the purpose. After harvesting, the crop is conveyed to the store where it undergoes a curing process in order to heal wounds sustained during lifting. This consists of maintaining a temperature in the store of 80° F. to 85° F. with a relative humidity of 90 per cent. and sufficient ventilation to prevent condensation of moisture for a period of ten days to two weeks. When the curing period is over the temperature of the storage house is reduced to as near 55° F. as possible, and maintained as near as possible at this figure and at a relative humidity of 85 to 90 per cent. throughout

the storage period. Such high humidities tend to check shrivelling and internal breakdown, and thus protect roots against infection.

Literature.—The following are some of the more important publications used in compiling the foregoing notes, from which further details may be obtained.

"Stored Grain Pests." By T. BAINBRIGGE FLETCHER. *Report of the Proceedings of the Third Entomological Meeting held at Pusa, February 3 to 15*, 1919, pp. 712-761. (Calcutta, India: Superintendent of Government Printing, 1920.)

"Airtight Storage of Grain." By HARNAM DASS BHASINE. *Report of the Proceedings of the Fifth Entomological Meeting held at Pusa, February 5 to 10*, 1923, pp. 228-230. (Calcutta, India: Superintendent of Government Printing, 1924.)

"Safeguarding Stored Grain against Insect Pests and Vermin." By R. O. WAHL. *Farming in South Africa*, **10**, No. 116, November 1935, pp. 455-456. (Pretoria, Union of South Africa: Department of Agriculture and Forestry.)

"Storage of Maize in Coastal Districts." By H. WENHOLZ. *Agricultural Gazette of New South Wales*, **38**, March 1, 1927, pp. 255-261; May 1, 1927, pp. 361-373. (Sydney: Alfred James Kent, Government Printer, 1928.)

"Corn Storage." By T. HUNTER. *The Journal of the Gold Coast Agricultural Society*, **5**, No. 2, July-September 1926, pp. 67-70. (Accra: Published at the Office of the Society, P.O. Box 206.)

"Rice Storage Experiments." By H. W. JACK and R. B. JAGOE. *The Malayan Agricultural Journal*, **18**, 1930, pp. 447-454. (Kuala Lumpur: Department of Agriculture.)

"The Storage of Padi in Kedah." By W. N. SANDS. *The Malayan Agricultural Journal*, **21**, 1933, pp. 678-681. (Kuala Lumpur: Department of Agriculture.)

"Storage of Sweet Potatoes." *United States Department of Agriculture, Farmers' Bulletin No.* 1442. (Washington, D.C.: Superintendent of Documents, 1934.)

"Sweet Potato Storage Trials." By J. G. BRASH. *Tropical Agriculture*, **8**, No. 7, July 1931, pp. 185-187. (Obtainable from the Imperial College of Tropical Agriculture, Trinidad, or the Secretary of the College, 14 Trinity Square, London, E.C.3.)

Avocado Oil.—The Avocado pear (*Persea americana* Mill. = *P. gratissima* Gaertn. f.) is one of the most widely grown of tropical fruits. A native of tropical America, the tree has been introduced into the tropics of the Old World, whilst varieties have been produced which have been found to succeed in less warm parts, such as South Africa and California. Generally speaking the Avocado can be grown under conditions suitable for Citrus fruits.

The fruit consists of an edible pulp surrounding a large, hard seed. As in the case of the olive, the pulp is rich in oil, which has long been extracted and used by the Central American natives. With a view to utilising the large quantities of cull fruit produced in California, an investigation on the nature of the oil was carried out by Jamieson, Baugham and Hann (*Oil and Fat Indust.*, 1928, **5**, 202). Oil extracted with ether

from the dehydrated pulp of the Fuerte variety was examined with the following results:

Specific gravity at 25°/25° C.		0·9132
Refractive index at 20° C.		1·4700
Acid value		2·8
Saponification value		192·6
Unsaponifiable matter	*per cent.*	1·6
Iodine number (Hanus)		94·4
Acetyl value		9·2
Reichert-Meisel number		1·7
Polenske number		0·2
Saturated acids (corrected)	*per cent.*	7·2
Unsaturated acids (corrected)	,,	84·3
Iodine number of unsaturated acids		101·2

The composition of the oil was determined and found to be as follows:

Glycerides of:	*Per cent.*
Oleic acid	77·3
Linolic acid	10·8
Myristic acid	Trace
Palmitic acid	6·9
Stearic acid	0·6
Arachidic acid	Trace
Unsaponifiable matter	1·6

The extracted oil was dark green by transmitted light and red by reflected light. The expressed oil was slightly lighter in colour and had but little odour and a pleasant fruity flavour; apart from its colour, it would probably be suitable as an edible oil. Experiments also showed that it could be used in combination with other fats for the manufacture of hard soap.

Later investigation has shown that Avocado oil is rich in Vitamins A, B, and D, when properly prepared. It also contains phytosterol and lecithin.

The special properties of the oil suggested its use for the preparation of cosmetics and it is for this purpose that most of the supplies are now employed.

The oil content of the pulp varies widely, according to the variety of fruit and the conditions under which it is grown. The average content of the three main groups into which the Avocado is classified is as follows, expressed on the fresh material: West Indian varieties, 4-7 per cent.; Guatemalan varieties, 10-13 per cent.; Mexican varieties, 12-15 per cent. In California the chief variety grown is the "Fuerte," produced by crossing Mexican and Guatemalan fruits, of which a number of strains are in cultivation. It is very resistent to cold and its season of ripening is exceptionally long. The highest grade is known as "Calavo," a copyright name of the fruit marketed by the Calavo growers of California, a growers' marketing organisation. The fresh edible portion of the "Calavo" may contain as much as 30 per cent. of oil.

Investigations in Florida have shown that the amount of oil in the pulp increases as the fruit ripens and the longer the fruit takes to reach maturity the higher is the percentage of oil. The oil content continues to increase even if the fruit is allowed to remain on the tree until well past the normal harvesting time for the variety.

The Florida experiments showed that the same variety almost invariably has an oil content several per cent. higher when grown in California than when grown in Florida. This is attributed to the different climatic conditions and the difference in time required to reach maturity in the two States. Similar results were recorded in experiments conducted some years ago in Trinidad. There were, however, certain exceptions in the Florida experiments. One variety, the "Dorothea," gave a higher oil content than in California, whilst another, the "Linda," a comparatively late-maturing variety in Florida, gave the same results in both States. This suggests that it might well be worth while carrying out selection experiments in places like the West Indies where hitherto a relatively low oil content has been the rule. It is somewhat doubtful, however, whether the more humid and warmer regions can produce fruits equal in oil content to the better Californian kinds.

At present Avocado oil is produced on a commercial scale only in California. The following account of the method of preparing the oil there is based on an article published in *The American Perfumer and Essential Oil Review*, for June 1934.

The oil is prepared from fruits of the "Calavo" type which are of good quality but are scarred or blemished and so are unsuitable for marketing as fresh fruit. Owing to the high proportion of moisture in the pulp of the mature fruit, which may reach nearly 70 per cent., it is not possible to extract the oil by pressure in the usual manner. At best only a stable emulsion of water and oil is obtained. Therefore, it is necessary to dehydrate the fruit before it is pressed. For this purpose it is peeled, the seed removed, the flesh sliced in thin strips, placed on drying trays and dehydrated in an atmosphere of either nitrogen or carbon dioxide at 130° F.

The dried slices are then ground and pressed without heat by a hydraulic press. A steel box frame hydraulic press, operating under a pressure of from about 3,000 to 4,000 lb. per sq. in. is best suited for this purpose. The press consists of a series of steel plates, set one above the other, about 5 in. apart when the press is wide open. These channeled plates are provided with close-fitting steel slides, so that the whole machine is really a series of boxes without ends, piled one upon the other, the lowest resting upon the hydraulic piston. The dehydrated fruit pulp is dropped upon a strip of press cloth in the cake former. When the cake is formed

a sheet of steel is slid beneath the cake, which is removed, cloth and all, and placed in the lowest frame of the press. When all the frames are thus charged, the hydraulic pressure is applied and the piston forces the frames upwards, each against the one above it. The oil squeezes through the cloths, flows over the sides of the press into the gallery around the bottom frame, and out through the trough to the settling tank. The crude oil contains some fine particles of fruit and must be allowed to stand in settling tanks till these have been deposited. The oil is then withdrawn and passed through a filter press. The clarified oil is deep red by reflected light and deep green by transmitted light, presenting a fluorescent appearance. It may be bleached to any desired degree, even to water white, but the expense is not justified, since most cosmetic manufacturers prefer the green oil, which is regarded as imparting richness and colour to the product in which it is used.

The oil is packed as soon as possible after clarifying in tins or drums, which are filled to their utmost capacity to exclude air. It is claimed that the oil has excellent keeping properties, and it would appear that no special precautions are required during transit and storage.

Great care is necessary in the preparation of the oil in order that its vitamin content may not be impaired.

The oil shipped to the United Kingdom comes in containers of various kinds, the principal being tins each containing one American gal. of 7½ lb. It has been suggested to the Imperial Institute, however, that a more satisfactory package would be 1 lb. and 5 lb. tins in cases of 25 lb. net.

Literature.—Further information on avocados with special reference to the oil will be found in the following publications :—

"Avocado Culture in California—Part II; Composition and Food Value." By M. A. JAFFA and H. GOSS. *Bull.* 365, 1923 (rev. 1928), *California Agric. Exp. Sta.*

"Some Changes in the Composition of California Avocados during Growth." By C. G. CHURCH and E. M. CHACE. *Bull. No.* 1073, 1922, *U.S. Dept. Agric.*

"Avocado Production in Florida." By H. S. WOLFE, L. R. TOY, and A. L. STAHL. *Bull.* 272, 1934, *Florida Agric. Exp. Sta.*

"Changes in Composition of Florida Avocados in Relation to Maturity." By A. L. STAHL. *Bull.* 259, 1933, *Florida Agric. Exp. Sta.*

"Composition of Trinidad Avocados." By H. S. SHREWSBURY. *Trin. and Tob. Bull.*, 1919, **18**, 134-135.

"Avocado Oil. The Composition and Constants of a Little-known Pericarp Oil." By G. S. JAMIESON, W. F. BAUGHMAN, and R. M. HANN. *Oil and Fat Industr.*, 1928, **5**, 202-206.

"Vitamin B content of Avocados." By L. S. WEATHERBY and E. W. WATERMAN. *Industr. Engng. Chem.*, 1928, **20**, 968-970.

"The Vitamin A content of Avocados." By L. S. WEATHERBY, J. E. YOUTZ, and R. V. WATSON. *J. Home Econ.*, 1929, **21**, 360-364. (Abstr. *Exp. Sta. Rec.*, 1930, **62**, 193.)

"Vitamins C, D, and E in Avocados." By L. WEATHERBY. *Calif. Avocado Ass. Yearbook*, 1930, pp. 100-105. (Abstr. *Exp. Sta. Rec.*, 1931, **64**, 587.)

"Sterol Content and Vitamin Value of Avocado Oil." *Rep. Hawaii Agric. Exp. Sta.*, 1931, p. 15; 1933, p. 23.

Products of the Empire.—Two interesting publications dealing respectively with agricultural and certain forest products of the Empire have recently been published by H.M. Stationery Office, viz., "Cultivated Crop Plants of the British Empire and the Anglo-Egyptian Sudan (Tropical and Sub-tropical)," by M. C. Sampson, C.I.E., B.Sc., F.L.S., issued as *Kew Bulletin Additional Series XII* (price 6s. 6d.), and "An Index of the Minor Forest Products of the British Empire," issued by the Imperial Economic Committee (price 5s.).

Mr. Sampson's work is intended primarily for officers of Agricultural Departments in the Overseas Empire who are concerned with trials with new crops or with selection work on those already in cultivation. It arose out of a resolution of the Conference of Colonial Directors of Agriculture held in 1931 and is based on the replies to a questionnaire issued by the Director of the Royal Botanic Gardens, Kew, and distributed to all tropical and sub-tropical countries of the Empire and to the Anglo-Egyptian Sudan. The first section (of 180 pages) consists of a list of all the principal cultivated crop plants arranged alphabetically under the generic names. The treatment of each species mentioned is the same throughout. After the Latin name is given any synonyms that may be in common use (an index to these is printed as an appendix), the country of origin, the common and vernacular names, and the product it yields. Then follows a list of the countries in which the crop is found, arranged in five categories, viz., (*a*) indigenous or an early introduction; (*b*) successfully introduced; (*c*) still under trial, or established on an acclimatisation station; (*d*) introduced, but the cultivation has subsequently disappeared or has been abandoned; (*e*) introduced, but has failed to become established. By this arrangement a vast amount of most valuable information has been compressed into as small a space as possible. The only regret we have to express is that room could not have been found for an index to the very large number of common and vernacular names mentioned.

The second part of the book, occupying about sixty pages, is entitled "Crop Notes," and gives information of special value to those engaged on variety trials. Over twenty of the more important crops have been selected for treatment. These comprise the chief cereals of the tropics (other than rice and maize), pulses (including groundnuts and soya beans), root crops, capsicums, cinchona, and sesame. In each case particulars are given of the characters which may prove useful in distinguishing varieties and references are included to appropriate literature dealing with this special aspect of the problem.

The "Index of the Minor Forest Products of the British

Empire" also is the outcome of a conference resolution, in this case one passed at the Imperial Conference of 1930. It has been compiled by the Imperial Economic Committee in consultation with the forest departments of the Empire and with the assistance of the Royal Botanic Gardens, Kew, and the Imperial Institute. In it the various minor forest products (defined as any product of the natural forest other than timber and its derivatives) are classified under drugs and spices, dyes, essential oils, fibres, gums and resins, oils and oil-seeds, tanning materials, and miscellaneous products. These sections, each prefaced by a short introduction, give for each commodity the trade name, the botanical species and the country of origin, and indicate whether an export trade has already been established, and, where it has not, whether in the opinion of local officers, the economic possibilities are favourable or slight. References are also given to a select bibliography from which more detailed information can be obtained. Some 580 products and over 500 species have been listed from 36 countries in the Empire, and over 400 bibliographical references are given. Reference to any particular product is rendered easy by the provision of alphabetical lists of the commodities and the species dealt with, whilst for those who wish to refer to the products of any particular region there is a separate list of the countries mentioned.

Boron Compounds and the Insect Menace.—It is well known that many infectious diseases of human beings and animals are carried by insects, the control of which is therefore a matter of great importance.

An article by J. Cossey (*Chem. Tr. J.*, 1936, **98**, 423) gives a useful account of the value of boron compounds in the war against insect pests. It is, of course, desirable to carry out the attack during the most vulnerable period of the life-cycle of the insect. For example, the house-fly invariably breeds in refuse or manure, and is best attacked on its breeding-grounds whilst in the egg or larval stage.

A larvicide should be, as far as possible, efficient, non-toxic to human beings and animals, economical, harmless to plant-life, and easy to obtain and apply, and a series of tests carried out in America showed that borax fulfilled these conditions, and constituted a very cheap and most efficient weapon; 2 lb. dissolved in 28 galls of water sufficed to treat 24 bushels of manure.

The common cockroach must, owing to its long life-cycle, be attacked at the adult, as well as the immature, stage. Poison-baits, containing borax as the toxic ingredient, are very efficient. Mosquitoes are exterminated in the larval stage by treating their breeding-places (stagnant pools, rain-

water butts, etc.) with sufficient borax to produce a concentration of 0·15 per cent. Red-mite, furniture-mite, ants, earwigs and moths can be repelled or exterminated, according to circumstances, by dusting-powders or poison-baits containing borax. In this connection, patents have been taken out for the use of compounds of borofluorides and organic acids as moth-proofing agents.

Skin-parasites are often eradicated by preparations containing borax, which is almost invariably a constituent of commercial insect-powders. The control of internal parasites is more difficult, but there is some evidence to show that the access of these pests to the bodies of animals can be prevented by the extermination of likely carriers. Such a step appears to be preferable to dosing young infected animals and incurring a risk of loss.

According to *Chem. Tr. J.*, 1936, **98**, 494, L. Ferri, of Milan, has carried out extensive experiments with the borates of the heavy metals (more especially tin, zinc and copper). He found that these were effective, even when greatly diluted, in the control of the organisms producing plant-rot and other diseases on vines, wheat, fruit-trees, etc. In these heavy-metal borates, the ratio between acid and basic radical can vary rather widely, but experiments showed that good results were obtained in spite of this variation. The results of the work are covered in English Patent 446,373 (1935), which includes a description of an improved method for the preparation of these borates.

Boric Acid and Borax for Fire-proofing Textiles.—Many processes for fire-proofing textiles have been recommended, and an account by R. Clarence (*Rev. Gen. Teint.*, 1936, **14**, 405) describes tests recently carried out to ascertain the conditions necessary for successful working of the boric acid and borax method of treatment.

Tests were made to determine the best ratio of boric acid to borax, and the amount of impregnating material required. Strips of cotton fabric were soaked in solutions of different concentrations containing mixtures of boric acid and borax, and were then dried. It was found that the material was rendered fireproof if it retained about 8 per cent. of a mixture of boric acid and borax containing 30 to 50 per cent. of boric acid. This process has been in use for some years and has given satisfactory results. In practice, it is usual to make some deviation from the above amounts as it has been found that textile materials do not always retain the two constituents in the proportions in which they occur in the soaking bath.

The influence of the treatment on the strength and colour of the fabric was also studied, and results showed that heating

to 100° C. did not diminish the strength of the impregnated fabric, but at temperatures of 140° C. or over the strength was greatly reduced. Boric acid alone has a considerable weakening action above 100° C. but the mixture has less effect than either of the constituents used separately.

Change in tint of the impregnated fabric may be brought about either by the effect of the chemicals on the dye or by a yellowing of the fabric under the influence of heat. In the first case, under the usual conditions of working—that is, soaking, and drying at 100° C.—the changes in tint are similar to those produced in an acid treatment, and it is therefore necessary to choose dyes which are fast to acids. Yellowing of the fire-proofed fabric was found to occur only at temperatures above 200° C., and, under ordinary conditions of use, should not affect materials treated by this process.

Mineral Statistics.—The 1933-1935 edition of the Imperial Institute "Statistical Summary of the Mineral Industry of the British Empire and Foreign Countries" has recently been issued. This volume contains 438 pages and, as in previous years, gives statistics of the production, imports and exports by the different countries of the world of 48 minerals, about half of which are metallic. The trade tables refer not only to the crude materials, but also to the chief semi-manufactured products, and in some cases the principal chemicals and derivatives. At the end of the volume will be found a list of the official publications from which the statistics have been compiled.

Copies can be obtained from the Imperial Institute, South Kensington, London, S.W.7.; price 7*s.* 6*d.* (8*s.* post free).

The Fuel Resources of the Union of South Africa.—According to the Fifth Annual Report of the Fuel Research Board, covering the work of the Fuel Research Institute (Pretoria, 1935), the resources of the Union consist for the most part of bituminous varieties of coal together with small quantities of lignite and oil shale. The coal seams are reported to underlie some 7,000 sq. miles of country, and though not numerous are often of considerable thickness, but composed of low-grade material which has been cindered in places by extensive dolerite intrusions. Despite this, large but not inexhaustible supplies of high-grade coal eminently suitable for hydrogenation and carbonisation purposes are available.

It is to be noted that while the reserves of one of the best South African gas coals are approaching exhaustion, the Fuel Research Institute has been successful in revealing two likely successors, one in the Witbank district, and the other at Vryheid.

Work is also being carried out on the preparation of an effective stabiliser for tars, obtained from South African coals by high temperature distillation, for which there is a considerable outlet in the construction of macadamised arterial roads. In the initial construction of such roads the tar is applied hot, but in subsequent repair work tar emulsions are being considered as a cheaper means of transporting the tar. To this end oleate soap has been found to be an inadequate stabiliser, and attention has been turned to such emulgents as casein.

The experimental work carried out upon the use of gas-producer units to replace petrol on road transport vehicles, is reported on briefly. It was found that on a 100 miles trip a 30 cwt. vehicle, fully loaded, consumed 1 gallon of petrol, employed chiefly in starting the engine, and 90-100 lb. of charcoal in the gas-producer, as against 8½ gallons of petrol for the trip when run on this fuel alone. No comparison of costs is given.

The work of the Fuel Research Institute also includes the sampling and analysing of coals for export and bunkers, as a check on the declared analyses of various collieries, since no coal can be sold for either purpose unless the colliery owners hold a grading certificate based on calorific value. The following grades are established by regulation :—

Natal Coal :

1st Grade : Minimum calorific value, 13·3 lb./lb.
2nd Grade : Calorific value below 13·3 lb./lb.

Transvaal Coal :

1st Grade : Minimum calorific value, 12·8 lb./lb.
2nd Grade : Minimum calorific value, 12·3 lb./lb.
3rd Grade : Minimum calorific value, 12·0 lb./lb.

It may be pointed out that the majority of the collieries hold the Natal or Transvaal 1st Grade certificate.

Possible New Uses for Canadian Natural Gas.—The greater part of the natural gas issuing from the oil and gas wells of Canada is allowed to blow to waste into the atmosphere ; and the following account, taken from the article by G. Stafford Whitby and Adrien Cambron (*Canad. Min. Metal. Bull.*, No. 292, 1936) outlines some of the uses to which this gas might be put.

The Turner Valley gas, which in 1935 was escaping at the rate of some 6,000 tons a day from the wells in this Alberta field, consists of about 75 per cent. methane, and the remainder, of the heavier hydrocarbon gases, ethane, propane and butane. Hitherto the only product obtained from the gas was naphtha, which was produced by passing the gas coming from the wells

at pressures varying between 1,200 and 1,800 lb. per sq. in. through separating cylinders, in which it expanded rapidly with a fall in pressure down to 300 lb. per sq. in., the refrigerating effect causing the naphtha to solidify. In order to remove the high proportion of occluded liquid and gas, the naphtha was then either distilled through a stabilising column or left to weather in open tanks until such time as the gas had evaporated.

More recently, oil-absorption plants have been employed to strip the raw gases of their petroleum and naphtha content. The gas remaining after such treatment is known as "dry gas" and is predominantly methane, whereas the gas driven off in stabilising the naphtha, called "stabiliser-gas," is chiefly propane and butane.

The National Research Laboratories, Ottawa, have established the fact that stabiliser gas when subjected to a suitable heat treatment (pyrolysis) can be converted into motor fuel at the rate of 3 gallons of motor fuel per 1,000 cu. ft. of gas pyrolised. The yield varies with the composition of the gas treated and is generally higher when gas rich in both propane and butane is used. The liquid resulting from the treatment, which takes place in a specially designed furnace at atmospheric pressure, is mainly benzol, which could be mixed to advantage with the straight Turner Valley petrol and thus raise its "knock-rating." It is estimated that some 8,000 galls. could be produced daily by means of this process from the supplies of stabiliser gas available in Alberta, and in addition provide, as by-products, about 2 tons of styrene, 3 tons of naphthalene, 2 tons of anthracene, and 60 tons of ethylene gas.

Among the many uses of these secondary products may be mentioned that of styrene and naphthalene for the manufacture of industrial plastic material and lacquers, and of naphthalene for the production of phthalic anhydride which is used in the manufacture of vat dyestuffs.

When suitable adjustments of temperature and rate of gas-flow through the furnace have been made, the pyrolysis process can be operated to yield gases of the olefine type of which ethylene is produced in largest quantity. This gas is being employed in the United States for the manufacture of synthetic ethyl alcohol in competition with that prepared by the fermentation of molasses. From the present output of natural gas in the Turner Valley, sufficient ethylene could be prepared, it is said, to provide over 20,000 galls. of ethyl alcohol a day. By an alternative procedure the ethylene could be converted to ethylene glycol, a liquid used extensively as an anti-freeze substance for automobile radiators, as the raw material for the manufacture of low-freezing point dynamite,

as a lubricant for the spinning of wool and largely, in the form of its ethers and esters, as lacquer solvents.

From chlorhydrin, the intermediate product in the conversion of ethylene to the glycol, many chemicals are made such as acrylic ester, used in the preparation of safety glass and mustard gas.

Dry gas, which is chiefly methane, is more difficult to utilise for purposes other than the production of carbon black by burning. Three installations are operating in the United States, however, one of which produces hydrogen from dry natural gas by thermal decomposition, and employs this gas in the manufacture of ammonia, another produces formaldehyde by the oxidation of methane under pressure, and in a third, acetylene is being produced from natural gas by subjecting it for a short time to an electric arc discharge. These processes might be employed successfully on Canadian natural gas, and furthermore the work of Dr. E. H. Boomer indicates that dry natural gas could, by passing it with air and steam over a heated catalyst, be converted to water gas, which has a variety of uses.

Tests of Mineral and other Pigments for Portland Cement Mortars.—In 1927, R. Wilson reported the results of exposure tests carried out for short periods on Portland cement mortar coloured with various pigments (*Proc. Amer. Concr. Inst.* 1927, **23**, 226). Some of these tests have been prolonged for nine years, and the results have now been described (*J. Amer. Concr. Inst.*, 1935, **7**, 228).

Wilson states that the mineral pigments which he tested (including various pure and impure oxides of iron, chromium oxide and carbon black) were not affected by exposure to weather in the presence of Portland cement. With most pigments six months exposure was sufficient to indicate the possibility of fading, but some varieties of ultramarine blue which did not fade within the first six months have subsequently deteriorated, while others have retained their colour.

The use of a durable pigment does not necessarily ensure a permanently coloured mortar surface, as the mortar itself may weather, causing a change in colour due to exposure of the aggregate. The formation of an efflorescence on the surface may also mask the colour and give the appearance of fading.

RECENT RESEARCH ON EMPIRE PRODUCTS

A Record of Work conducted by Government Technical Departments Overseas

AGRICULTURE

MANURES

Nigeria.—The following statement is contained in the half-yearly report of the Chemical Section (Southern Provinces) of the Agricultural Department for January to June, 1936.

As additions of ground rock phosphate appeared to have a more marked effect after the growth and incorporation of a green manure crop (*Calopogonium* or *Mucuna*) experiments are being conducted in order to find out if the rotting of the green manure has any effect in increasing the water-soluble phosphate in ground rock phosphate. The results at present have proved definitely negative.

The nitrate production of the leaves of a leguminous green manure crop (*Mucuna utilis*) against a non-leguminous crop (*Ipomoea* sp.) was studied by incorporating equal weights of the leaves of each plant with equal weights of soil and leaching out the nitrates with water every week for four months. It was found that the nitrate production was slightly in favour of the non-leguminous plant.

COVER CROPS

Uganda.—According to the half-yearly report on the Kampala Plantation for January to June, 1936, a considerable number of green manure and other leguminous crops are being grown there. Of these the most useful under conditions at Kampala are velvet bean (*Mucuna pruriens*), sword bean (*Canavalia ensiforme*), pigeon pea (*Cajanus cajan*) and sunn hemp (*Crotalaria juncea*).

The velvet bean grows and spreads rapidly and soon forms a cover over the soil; it is sown on many of the fallow plots.

The sword bean, with its erect, non-climbing habit, is used for interplanting among coffee as well as for covering fallow ground: it has the further advantage that it grows quite well under shade.

The pigeon pea is useful as a long term cover crop; the form that is grown at Kampala will last two years at least.

The sunn hemp is a short period crop, germinating rapidly and, when sown densely, it will provide a large bulk of material within a few months.

Species of *Phaseolus* (*P. calcaratus* and some forms of *P. lunatus*, such as Madagascar butter beans) will form a good

cover for a space of one to two years, but their climbing habit makes it necessary for attention to be given frequently if they are interplanted among coffee.

Sesbania aegyptiaca is a tall shrub, attaining a height of 20 feet and with an open habit; it is sometimes used to give temporary shade, for it will last for two years at Kampala: also it will tolerate very swampy conditions, and therefore it is used for planting in some of the wetter parts of the plantation.

Of permanent ground cover crops, those most used are *Leucaena glauca*, which must, however, be cut back periodically, and *Centrosema pubescens*. The latter species has the disadvantage that it cannot compete with the local "Lumbugu" or couch grass (*Digitaria scalarum*) and, in consequence, if a plot has been under *Centrosema pubescens* for some time, a dense growth of "Lumbugu" may have formed. *Centrosema plumieri* shows promise of being a good cover crop, but, unfortunately, it sets very little seed at Kampala.

Beverages

Cacao

Gold Coast.—A report on the investigations conducted during the period January to June, 1936, furnished by the Director of Agriculture, contains the following statement relating to cacao:

Testing the Use of Fertilizers.—Experiments on the effect of artificial manures on cacao, which have been continued for seven years, indicate that no single artificial, or combination of them, produces increases in yield which repay the cost of their application; indeed a simple system of combined forking and mulching without fertilizers has given better results than any obtained by the use of artificials. The application of sulphate of potash by itself has detrimental effects.

Substitution of Steel for Lead Seals.—Towards the end of 1935 requests were made by American manufacturers that the Department should discontinue the use of lead seals on cocoa bags, as traces of lead had been found in chocolates. It was alleged that there was no possible source of lead contamination other than the official seals used on bags, and finally European users associated themselves with the complaint. In deference to the general wish, the Department has therefore distributed for use as from mid-June a steel seal, which is readily caught in the magnetic separators used in factories for the preliminary cleaning of bulk supplies of cocoa.

Relative Importance of Cocoa Producing Areas.—These are

shown in the following table, which allocates the tonnage marketed during the crop year 1934-35 :—

	Tons.
Eastern Division . .	110,000
Ashanti. . . .	86,000
Central Division . .	51,000
Trans-Volta . . .	16,000
Western Division . .	13,000
	276,000

Coffee

Uganda.—The following information relating to experiments with coffee carried out by the Department of Agriculture at the Kampala Plantation and the Bukalasa Experiment Station is contained in the half-yearly report for January to June 1936 :

Kampala.—The rain, which fell at frequent intervals during December, January and February—months which usually are dry but which this year had a rainfall of 6·97 in., 3·79 in. and 2·59 in. respectively—adversely affected the flowering of Arabica coffee and hardly a single flower opened in the normal manner ; only small green star-shaped flowers resulted. With Robusta coffee, on the other hand, although there was no well-marked burst of flowering, yet there have been several small flushes of flowers and a fair quantity of fruit has set.

Experiments on the vegetative propagation of coffee have been in progress on the plantation for some years, and it is now possible to make some observations on the results obtained. The first experiments were on the practice of cleft grafting—with scions both of Arabica and Robusta coffee on stocks of Robusta, Liberica and Excelsa seedlings. Clones of selections were planted out in 1932 : although they are on some of the best soil that is available, yet their growth has not been so strong as that of seedlings. This weakness has been especially marked in the case of Arabica coffee—none of the trees are really robust, and many have died off suddenly, a phenomenon which would appear to be due to incompatibility of the stock and the scion and the formation of a poor union between the bark of the two species. The Robusta clones are mostly in good condition—only a few individuals have died : it is remarkable how similar the trees in any one clone appear to be, in spite of the diversity of stocks employed.

Experiments also were made with grafting selected Robusta trees on older trees of poor type and the scions made strong growth ; but it is now difficult to sucker such plants, for it is hard to tell whether shoots arise from the stock or from the

scion—this disadvantage could be overcome by marking the point of union with paint, as is done in the Dutch East Indies.

More recently, trials have been made with cuttings, and a fair amount of success has been obtained in the case of Robusta coffee, using large cuttings, about eighteen inches long, of woody branches; only a few Arabica coffee cuttings of this type have grown. The oldest rooted cuttings were planted out in 1934 and have made quite good growth, although they appear to suffer more from drought than do seedling plants.

Bukalasa.—In the shade and cover crop experiment there was a general levelling up of yields, and the most significant result was the continued loss in crop due to the use of banana shade with a cover crop.

In the ground treatment experiment, it was found that mulching and clean weeding gave similar yields, both producing very much greater crops than a permanent cover crop and selective weeding. The value of mulch for checking erosion and weeds was very evident. The results are shown in the following table:

Yields

(Totals of four one-ninth acre plots)

	lb. of wet cherry.
Clean weeding	5,428
Mulching	5,275
Permanent cover crop	2,076
Selective weeding	1,032
Least significant difference	1,109·2

SUGAR

Cane

Leeward Islands. *Antigua.*—The following account of experiments with sugar cane is contained in the report on investigational work conducted in Antigua during July-December 1935:—

I. Experiments in Connection with the Germination of Sugar Cane

In some parts of Antigua considerable difficulty in establishing fields of plant cane is frequently experienced as a result of irregularities in germination. Soaking the cuttings in water or in lime water has been advocated and at times the practice has proved of value while on other occasions no benefits have resulted.

Experiments with the varieties B.891 and B.726 unsoaked, soaked in water, in lime water, in ½ per cent. solution of ferrous sulphate, and in lime water with magnesium sulphate, have been conducted in Barbados during the period 1930-1933 (*Agric. J. Barbados*, 1933, **2**, No. 3, 20-25). Under dry conditions B.891 cuttings soaked for 48 hours in ferrous sulphate solution or in lime water germinated better than when soaked in water alone or in lime water with magnesium sulphate, both of which treatments in turn gave better germinations than the unsoaked cuttings. Under wet conditions the cuttings soaked in water alone showed a significantly slightly lower germination than those from the other four treatments. There was no significant difference between the germinations in cuttings from these four treatments. Under wet conditions B.726 germinated well with all treatments, but treatment with ½ per cent. ferrous sulphate did not give quite so high a percentage germination as the others.

Germination trials have also been conducted in Mauritius with White Tanna and with B.H.10/12 (*Third Annual Report of the Sugar Cane Research Station, Dept. Agric., Mauritius*, pp. 45-66). The former variety was soaked for 24 hours and the latter for eight hours. In both cases all treatments gave good germinations. Soaking in lime water and soaking in water alone, however, greatly increased the speed of germination and the final germination figures were slightly higher than in the case of unsoaked cuttings.

C. F. Charter (in an unpublished communication) has shown that the germination of cane cuttings, especially in the case of B.147 (B.4507)—a variety generally recognised as one established only with difficulty—can be greatly increased and accelerated by soaking for 48 hours in saturated lime water.

Two experiments have been conducted at Greencastle Experiment Station to determine the effect on germination both under wet and under dry conditions of soaking for 48 hours (*a*) in water, (*b*) in lime water, the varieties B.H.10·12, B.147 (B.4507), Ba.11569 and P.O.J.2878—the four varieties most extensively cultivated in Antigua.

In each case the layout was six randomised blocks, the individual plots consisting of two rows containing 24 setts per row. The setts were all planted flat and spaced one foot apart.

The " wet planting " experiment was planted on December 13, 1934. The rainfall during November and December 1934 and January 1935 was 11·48 in., 6·60 in. and 3·94 in. respectively.

Table 1 shows the final germination figures for this experiment two months after planting.

Table I—Wet Season Germination Experiment

Block.	B.H. 10.12.			B. 147 (B. 4507)			Ba. 11569.			P.O.J. 2878.		
	Not Soaked	Water	Lime Water	Not Soaked	Water	Lime Water	Not Soaked	Water	Lime Water	Not Soaked	Water	Lime Water
A	37	37	41	27	38	46	46	31	44	37	29	32
B	41	34	42	26	37	46	38	30	43	28	21	37
C	37	38	43	19	31	45	41	39	43	37	25	36
D	36	27	46	32	34	47	41	36	42	28	19	34
E	41	25	47	28	38	47	42	35	42	29	23	32
F	34	38	42	25	26	46	41	34	45	39	10	35
Total	226	199	261	157	204	277	249	205	259	198	127	206
Mean . .	37·7	33·1	43·5	26·2	34	46·2	41·5	34·2	43·2	33	21·2	34·3
Percentage .	78·5	69·2	90·7	54·5	70·8	96·0	86·5	71·2	90·0	68·8	44·2	71·5
	Significant Difference 12·6% Prob. 0·05			Significant Difference 11·9% Prob. 0·01			Significant Difference 9·9% Prob. 0·01			Significant Difference 20% Prob. 0·01		

In the case of each variety the germination of the cuttings soaked in lime water has been better than that of the unsoaked cuttings although a significant difference has been proved only in the case of B.147 (B.4507).

In each case lime water treatment is significantly better than water treatment.

Soaking B.147 (B.4507) in water has given a significantly greater germination than that obtained with unsoaked cuttings. In the case of Ba.11569 and P.O.J.2878 water soaking has significantly depressed germination.

Lime water treatment has also accelerated germination especially in the case of B.147 (B.4507). This is shown in the following table which contains mean germination figures at 18 days and 25 days after planting.

Time.	B.H. 10.12.			B. 147 (B. 4507).			Ba. 11569.			P.O.J. 2878.		
	Not Soaked	Water	Lime Water	Not Soaked	Water	Lime Water	Not Soaked	Water	Lime Water	Not Soaked	Water	Lime Water
18 days	27	21	32	1	17	28	13	15	22	7	10	20
25 days	35	27	39	8	26	42	28	29	38	18	17	32

The planting material used in the experiment was obtained from plant canes. The respective ages were: B.H.10·12, 7 months; B.147 (B.4507), 11 months; Ba.11596, 9 months; P.O.J.2878, 12 months.

The "dry planting" experiment was planted on March 16, 1935. The rainfall during February, March and April 1935 was 1·89 in., 1·18 in. and 2·45 in. respectively.

Table 2 shows the final germination figures for this experiment 7 weeks after planting.

Table II—Dry Season Germination Experiment

Block.	B.H. 10.12.			B. 147 (B. 4507).			Ba. 11569.			P.O.J. 2878.		
	Not Soaked	Water	Lime Water	Not Soaked	Water	Lime Water	Not Soaked	Water	Lime Water	Not Soaked	Water	Lime Water
A	35	19	13	36	15	14	39	15	40	41	25	35
B	42	6	30	35	28	18	32	33	21	36	32	30
C	12	17	30	26	21	15	28	27	33	22	16	30
D	37	19	21	32	13	14	34	19	36	34	25	33
E	24	11	33	35	23	10	38	4	37	36	29	30
F	38	3	33	37	21	28	41	20	47	38	25	32
Total	188	75	160	201	121	99	212	118	214	207	152	190
Mean . .	31·3	12·5	26·7	33·5	20·2	16·5	35·3	19·7	35·7	34·5	25·3	31·3
Percentage .	65·3	26·1	55·6	69·8	41·9	34·3	73·7	40·9	74·1	71·8	52·8	65·9
	Significant Difference 28·2% Prob. 0·05			Significant Difference 7·5% Prob. 0·01			Significant Difference 24·5% Prob. 0·05			Significant Difference 11·3% Prob. 0·05		

In every case soaking in water has significantly decreased the germination percentage and in the case of B.147 (B.4507) lime water treatment has resulted in a greater reduction than soaking in water alone. In no case has soaking in lime water proved beneficial.

The planting material used in this experiment was obtained from plant cane. The respective ages of the varieties were :— B.H.10·12, Ba.11569 and P.O.J.2878, 14 months; B.147 (B.4507), 16 months.

On repeating a germination trial with B.147 (B.4507) in April 1935, during wetter weather, lime water soaking again caused increased germination, viz. soaked 98 per cent., unsoaked 69 per cent.

As a possible explanation of the anomalous behaviour of B.147 when planted under dry conditions it has been suggested that the dryness of the soil at the time of planting and for some time after was more injurious to plants which started to germinate as the result of soaking in lime water than to plants which germinated more slowly without this treatment.

Considerable increases in germination followed lime water treatment of B.726 and B.891—ratoon cane material—planted under wet conditions. The final germination counts were as follows :—

	Per cent.		Per cent.
B.726 untreated	25·8	B.891 untreated . . .	16·9
B.726 lime water treatment .	88·3	B.891 lime water treatment .	79·4

The above experiments indicate that under wet conditions germination is stimulated by soaking for 48 hours in saturated lime water, but that under dry conditions this treatment can produce the reverse effect.

Soaking in water alone, save in the case of B.147, has had an injurious effect and it is suggested in view of this fact that failure to obtain increased germination on soaking in lime water and planting under wet conditions may at times have been due to the use of poor lime, the soaking liquid being essentially a suspension of insoluble calcium carbonate rather than a solution of calcium hydroxide.

II. Experiments with Plant Cane

These experiments, together with the cultural and manurial experiments in subsequent sections of the report, form part of a comprehensive series of experiments conducted by the Department of Agriculture and by Mr. C. F. Charter, Agronomist to the Gunthorpes Estates, under the direction of Mr. P. E. Turner, Adviser in Sugar Cane Experiments to the Commissioner of Agriculture, and under the auspices of the Sugar Cane Investigation Committee of Antigua.

The preliminary results of this experimental scheme have been published in *Tropical Agriculture*, January and February 1936.

Varietal Trial, Thibous Estate

Soil Type: Calcareous marl, shallow phase.
Planted: December 20, 1933.
Reaped: February 28, 1935.
Rainfall:

			Average rainfall for similar period based on returns for 10 years:	
Dec. 1933 .	2·72 in.		Dec. . . .	2·77 in.
1934 .	33·75 ,,		Jan.-Dec.	36·40 ,,
Jan.-Feb. 1935 .	1·54 ,,		Jan.-Feb.	2·89 ,,
Total .	38·01 ,,		Total . . .	42·06 ,,

Layout: Five randomised blocks. Plot size $\frac{1}{32}$ acre.

Variety.	Yield tons per acre. Cane.	Sugar.	Sucrose in Juice. lb. per gal.
Ba.11569 . .	17·17	2·35	2·036
B.2935 . .	16·10	2·26	2·096
P.O.J.2878 .	13·11	1·64	1·799
S.C.12.4 . .	10·65	1·33	1·862
B.147 (B.4507)* .	7·73	0·90	1·713

* *There has long been uncertainty as to whether or not the two varieties cultivated in Antigua as B.147 and B.4507 were really two varieties or not. It seems probable that only one variety is cultivated, viz., B.147.*

All the varieties with the exception of B.147 germinated well and were established without difficulty.

Differences between mean yields of cane exceeding 5·62 tons are statistically significant. The yield of Ba.11569 is

significantly greater than that of S.C.12·4 and of B.147. The yield of B.2935 is significantly greater than that of B.147.

A difference of 0·76 tons of sugar per acre is necessary for statistical significance. The varieties Ba.11569 and B.2935 give significantly larger yields of sugar to the acre than S.C.12·4 and B.147.

Varietal Trial, Collins Estate

Soil Type: Calcareous marl.
Planted: December 28, 1933.
Reaped: February 12, 1935.
Rainfall:

			Average rainfall for similar period based on returns for 10 years:	
Dec. 1933	.	2·12 in.	Dec. . .	2·93 in.
1934	.	40·08 „	Jan.-Dec. . .	38·31 „
Jan.-Feb. 1935	.	2·14 „	Jan.-Feb. . .	3·32 „
Total	.	44·34 „	Total .	44·56 „

Layout: Four randomised blocks. Plot size $\frac{1}{30}$ acre.

Variety.	Yield tons per acre. Cane.	Sugar.	Sucrose in Juice. lb. per gal.
B.2935 . .	28·59	3·47	1·820
Ba.11569 . .	28·08	3·70	1·950
B.H.10.12 . .	26·30	3·84	2·181
P.O.J.2878 .	25·24	3·61	2·135
S.C.12.4 . .	22·54	3·20	2·114
B.147 (B.4507) .	22·28	2·79	1·854
B.726 . .	22·11	3·41	2·309

The varieties B.147 and S.C.12·4 were difficult to establish and made a poor start. B.2935 germinated well, but subsequently a number of the young plants in one plot were killed by weevil borer.

Differences between two mean yields of cane exceeding 4·79 tons per acre are statistically significant. The yields of B.2935 and Ba.11569 are significantly greater than those of S.C.12·4, B.147 and B.726.

A difference of 0·49 tons of sugar per acre is necessary for statistical significance. The variety B.H.10·12 rises from fourth place to first place when allowance is made for juice quality.

Varietal Trial, Paynters Estate

Soil Type: Non-calcareous clay tuff.
Planted: January 9, 1934.
Reaped: March 21, 1935.
Rainfall:

			Average rainfall for similar period based on returns for 10 years:	
Dec. 1933	.	3·71 in.	Dec. . .	3·00 in.
1934	.	46·41 „	Jan.-Dec. .	39·93 „
Jan.-Mar. 1935	.	4·06 „	Jan.-Mar. . .	5·07 „
Total	.	54·18 „	Total .	48·00 „

Layout: Four randomised blocks. Plot size $\frac{1}{30}$ acre.

Variety.	Yield tons per acre. Cane.	Sugar.	Sucrose in Juice. lb. per gal.
B.2935 . .	32·96	4·57	2·059
Ba.11569 . .	30·48	4·18	2·041
P.O.J.2878 .	29·70	3·93	1·973
S.C.12.4 . .	29·37	4·18	2·124
B.H.10.12 . .	26·95	4·35	2·332
B.726 . .	26·30	3·97	2·254
B.147 (B.4507) .	25·25	3·05	1·794

In this experiment B.H.10.12 was not properly established until after supplying.

A difference between any two mean yields of cane must exceed 3·66 tons per acre for statistical significance. The yield of B.2935 is significantly greater than those of B.H.10.12, B.726 and B.147. The yields of Ba.11569 is significantly greater than those of B.726 and B.147 while P.O.J.2878 and S.C.12·4 are significantly better than B.147.

A difference of 0·56 tons per acre is necessary for statistical significance. B.2935 is significantly better than B.726 and B.147. B.147 is significantly poorer than the other varieties.

The following general comments on the varieties under comparison may be of interest.

Ba.11569 and B.2935 have done well in the experiments. The former cane, despite poor germination at times and only moderately good juice qualities, appears to be the nearest approach of the established varieties to a general purpose cane in Antigua. In most fields it shows leaf symptoms of gumming disease but is sufficiently resistant to this disease to warrant general planting until a more suitable variety is forthcoming.

B.2935 germinates readily and is likely to compete with Ba.11569 on many soils provided it ratoons well.

P.O.J.2878 germinates well. In all these experiments it made the most rapid early growth but ultimately gave place to other varieties. It is unsuited to conditions of low rainfall.

B.H.10.12 requires an annual rainfall exceeding 40 in. and a well-drained soil. Under these conditions it is capable of giving satisfactory yields of cane and of sugar.

S.C.12.4 has not done particularly well in any of the trials. General field experience in Antigua indicates that except in limited localities it is not suited to Antigua conditions.

B.726 germinated fairly well but has given poor results in the trials here reported. Field experience indicates that it is well suited to conditions in the Bendals and Jolly Hill districts.

B.147 has given poor results in the three trials. Field experience, however, indicates that it is a valuable cane on the marl soils especially in virtue of its drought resistance and good ratooning power. Its germination is uncertain and its early growth slow, two drawbacks which can be

overcome by soaking the setts in lime water and by earlier planting respectively.

III. Manurial and Cultural Experiments

(A). Optimum Size of Dressing of Pen Manure and Pen Manure v. Sulphate of Ammonia (plant canes)

Gaynors Estate

Soil Type: Calcareous marl.
Rainfall: (14½ months) 35 in.
Variety: Ba.11569.
Layout: Two 4×4 Latin squares and four randomised blocks
Plot size: $\frac{1}{38}$ acre.
Planted: February 8, 1934
Manured: July 5, 1934
Reaped: April 16, 1935.

Treatment.	Yield. tons per acre.	Gain in Yield. tons per acre.
No manure	26·56	—
12 tons pen manure per acre . . .	32·65	6·09
24 „ „ „ „ „ . . .	34·62	8·06
4 cwts. Sulphate of Ammonia per acre .	26·90	0·34
2 „ July 12, 1934.		
2 „ August 31, 1934.		

The pen manure used in this experiment was of excellent quality and far superior to the average product. It was applied in the furrows between the stools of cane.

The gain in yield due to pen manure is statistically significant and might be due to chance far less than once in 100 times.

There was practically no gain in yield from the sulphate of ammonia: the small difference observed is not significant.

The results of this experiment indicate that as far as the plant canes are concerned it would be preferable to apply pen manure to the whole area cultivated at the rate of 12 tons per acre than to apply a larger dressing to portion of the area and to leave the remainder without pen manure.

(B). Optimum Size of Dressing of Filter-Press Mud and Filter-Press Mud v. Pen Manure (plant canes)

Yeamans Estate

Soil Type: Calcareous marl.
Rainfall: (13 months) 41 in.
Variety: Ba 11569.
Layout: Two 5×5 Latin squares.
Plot size: $\frac{1}{20}$ acre.
Planted: March 2, 1934.
Manured: July 10, 1934.
Reaped: April 5, 1935.

Treatment.	Yield. tons per acre.	Gain in Yield. tons per acre.
No manure	31·76	—
3 tons filterpress mud per acre	35·73	3·97
6 „ „ „ „ „ „	36·33	4·57
9 „ „ „ „ „ „	37·12	5·36
10 „ pen manure per acre .	35·57	3·87

The filter press mud and the pen manure were applied in the furrows between the cane stools. The pen manure was of average quality.

The gains in yield due to filter press mud and pen manure are statistically significant and might be due to chance less than once in 100 times. About 3 tons of filter press mud per acre appears to be the economic application and equals about 10 tons pen manure of average quality.

(*C*). *Sulphate of Ammonia on plant canes growing on soil which has not received Pen Manure*

Betty's Hope Estate

Soil Type: Lagoon clay. 1·6 per cent. $CaCO_3$.
Rainfall (14½ months): 42 in.
Variety: Ba.11569.
Layout: Seven randomised blocks.
Plot size: $\frac{1}{25}$ acre.
Planted: December 22, 1933.
Reaped: March 16, 1935.

Treatment. Sulphate of Ammonia per acre. March 1934	Aug.-Sept. 1934.	Yield. tons per acre.	Gain in Yield. tons per acre.
Nil	Nil	29·40	—
Nil	2 cwts.	32·42	+3·02
Nil	4 cwts.	32·31	+2·91
2 cwts.	2 cwts.	28·78	−0·62
2 cwts.	4 cwts.	29·90	+0·50

Late dressings of sulphate of ammonia have produced a gain in yield of 3 tons per acre. This increment though small is significant.

Yorkes Estate

Soil Type: Non-calcareous.
Rainfall (11 months): 35 in.
Variety: B.H.10.12.
Layout: Two 5 × 5 Latin squares.
Plot size: $\frac{1}{32}$ acre.
Planted: April 7, 1934.
Reaped: March 7, 1935.

Treatment. Sulphate of Ammonia per acre. April 1934.	Aug.-Sept. 1934	Yield. tons per acre.	Gain in Yield. tons per acre.
Nil	Nil	11·85	—
Nil	2 cwts.	12·40	+0·55
Nil	4 cwts.	12·25	+0·40
2 cwts.	2 cwts.	11·95	+0·10
2 cwts.	4 cwts.	12·50	+0·70

In no case is the increase in yield significant. The experimental field was cultivated during the wet season of 1933 and was in somewhat poor tilth. The rainfall, 35 in. during the growing period, was badly distributed, 15·79 in. falling during November and December. The possible significance of these factors will be discussed later.

Jolly Hill Estate

Soil Type: Alluvial. Non-calcareous.
Rainfall (16 months): 42·73 in.
Variety: B.H.10.12.
Layout: One 6 × 6 Latin square.
Plot size: $\frac{1}{30}$ acre.
Planted: January 6, 1934.
Reaped: May 2, 1935.

	Treatment. Sulphate of Ammonia per acre. March.	August.	Yield. tons per acre.	Gain in Yield. tons per acre.
Banks broken	Nil	Nil	16·35	—
,, ,,	2 cwts.	2 cwts.	18·10	+1·75
,, ,,	Nil	2 cwts.	15·90	−0·45
Banks not broken	Nil	Nil	18·00	—
,, ,, ,,	2 cwts.	2 cwts.	16·45	−1·55
,, ,, ,,	Nil	2 cwts.	17·70	−0·30

The mean yield for the 12 no Nitrogen plots was 17·2 tons per acre.
The mean yield for the 12 2-cwt. Sulphate of Ammonia plots was 16·8 tons per acre.
The mean yield for the 12 4-cwt. Sulphate of Ammonia plots was 17·4 tons per acre.

Sulphate of ammonia has not caused an increase in yield. As was the case at Yorkes the field was cultivated in the rainy season of 1933 and was not in good tilth and the rainfall distribution was poor, nearly 16 in. falling during November and December 1934.

Cochranes Estate

Soil Type: Calcareous clay tuff. 8·3 per cent. $CaCO_3$.
Rainfall (12¾ months): 39 in.
Variety: Ba.11569.
Layout: One 6 × 6 Latin square.
Plot size: $\frac{1}{33}$ acre.
Planted: March 29, 1934.
Reaped: April 23, 1935.

	Treatment. Sulphate of Ammonia per acre. August.	October.	Yield. tons per acre.	Gain in Yield. tons per acre.
Banks broken	Nil	Nil	36·0	—
,, ,,	2 cwts.	2 cwts.	38·6	+2·6
,, ,,	2 cwts.	Nil	38·4	+2·4
Banks not broken	Nil	Nil	37·5	—
,, ,, ,,	2 cwts.	2 cwts.	36·1	+0·1
,, ,, ,,	2 cwts.	Nil	38·3	−1·2

The mean yield for the 12 no Nitrogen plots was 36·75 tons per acre.
The mean yield for the 12 2-cwt. Sulphate of Ammonia plots was 38·35 tons per acre.
The mean yield for the 12 4-cwt. Sulphate of Ammonia plots was 37·35 tons per acre.

The increments due to sulphate of ammonia are very small and are not statistically significant.

The effect of Breaking of Banks in the two experiments above are discussed in a later section of this report (p. 506).

(*D*). *Sulphate of Ammonia v. Nitrate of Soda on plant canes growing on soil which has not received Pen Manure*

Parham Lodge Estate

Soil Type: Calcareous marl, deep phase. 24 per cent. $CaCO_3$.
Rainfall (15 months): 49 in.
Variety: Ba.11569.
Layout: Two 5×5 Latin squares.
Plot size: $\frac{1}{24}$ acre.
Planted: December 29, 1933.
Reaped: March 27, 1935.

Treatment. Applied in June.	Applied in August.	Yield. tons per acre.	Gain in Yield. tons per acre.
Nil	Nil	27·83	—
42 lb. N. as Sulphate of Ammonia.	Nil	26·80	−1·03
42 lb. N. as $NaNO_3$.	Nil	25·85	−1·95
42 lb. N. as Sulphate of Ammonia.	42 lb. N. as Sulphate of Ammonia.	26·74	−1·09
42 lb. N. as $NaNO_3$.	42 lb. N. as $NaNO_3$.	26·89	−0·94

The decreases are not significant.

Ffryes Estate

Soil Type: Calcareous. 16·4 per cent. $CaCO_3$.
Rainfall ($13\frac{1}{2}$ months): 40 in.
Variety: B.H.10.12.
Layout: Two 5×5 Latin squares.
Plot size: $\frac{1}{30}$ acre.
Planted: February 15, 1934.
Reaped: April 10, 1935.

Treatment. Applied in June.	Applied in August.	Yield. tons per acre.	Gain in Yield. tons per acre.
Nil	Nil	21·71	—
42 lb. N. as Sulphate of Ammonia.	Nil	22·26	+0·55
42 lb. N. as $NaNO_3$.	Nil	21·20	−0·51
42 lb. N. as Sulphate of Ammonia.	42 lb. N. as Sulphate of Ammonia.	19·87	−1·84
42 lb. N. as $NaNO_3$.	42 lb. N. as $NaNO_3$.	20·30	−1·41

Average yield no-Nitrogen plots, 21·71 tons per acre.
Average yield 42-lb. Nitrogen plots, 21·73 tons per acre.
Average yield 84-lb. Nitrogen plots, 20·09 tons per acre.

The average yield on the high nitrogen plots is significantly smaller than on the plots without nitrogen and with 42 lb. of nitrogen.

(*E*). *Sulphate of Ammonia on first ratoons*

Blubber Valley Estate

Soil Type: Alluvial. Non-calcareous.
Rainfall ($13\frac{1}{2}$ months): 38 in.
Variety: B.H.10.12.
Layout: One 4×4 Latin square and four randomised blocks.
Plot size: $\frac{1}{24}$ acre.
Reaped as plant canes: March 23, 1934.
Manured: May 15, 1934.
Reaped: May 7, 1935.

Treatments. Sulphate of Ammonia per acre.	Yield. tons per acre.	Gain in Yield. tons per acre.
Nil	10·33	—
2 cwts.	14·98	4·65
4 cwts.	16·58	6·25
6 cwts.	17·08	6·75

Pen manure (quantity unknown) was applied to the field as plant cane.

The gains in yield due to sulphate of ammonia are significant and might be due to chance far less than once in 100 times.

Diamond Estate

Soil Type: Calcareous marl, deep phase. 29·7 per cent. $CaCO_3$.
Rainfall (13 months): 43 in.
Variety: B.H.10.12.
Layout: Four 4×4 Latin squares.
Plot size: $\frac{1}{81}$ acre.
Reaped as plant cane: March 20, 1934.
Manured: May 17, 1934.
Reaped: April 28, 1935.

Treatments. Sulphate of Ammonia per acre.	Yield. tons per acre.	Gain in Yield. tons per acre.
Nil	14·65	—
2¼ cwts.	16·03	1·38
4½ cwts.	17·76	3·11
6¾ cwts.	18·21	3·56

No manure was applied to this field as plant cane. The gains in yield due to sulphate of ammonia although small are definitely significant and might be due to chance less than once in 100 times.

(*F*). *Sulphate of Ammonia v. Nitrate of Soda on First Ratoons*

La Roches Estate, Field No. 3

Soil Type: Slightly calcareous clay tuff. 1·1 per cent. $CaCO_3$.
Rainfall (11½ months): 39 in.
Variety: Ba.11569.
Layout: Four 4×4 Latin squares.
Plot size: $\frac{1}{29}$ acre.
Reaped as plant canes: June 12, 1934.
Manured: July 10, 1934.
Reaped: May 21, 1935.

Treatments.	Yield. tons per acre.	Gain in Yield. tons per acre.
No manure (mean of 32 plots) .	21·03	—
60 lb. N. as Sulphate of Ammonia	28·00	6·97
60 lb. N. as $NaNO_3$	27·28	6·25

25 tons of pen manure was applied to the field as plant cane. The increments due to nitrogen are highly significant and are economic. There is nothing to choose between sulphate of ammonia and nitrate of soda.

Fitches Creek Estate, Field No. 5

Soil Type: Calcareous marl, deep phase. 15·3 per cent. $CaCO_3$.
Rainfall ($13\frac{1}{2}$ months): 50 in.
Variety: B.147 (B.4507).
Layout: Four 4×4 Latin squares.
Plot size: $\frac{1}{80}$ acre.
Reaped as plant canes: April 1934.
Manured: July 11, 1934.
Reaped: May 28, 1935.

Treatment.	Yield. tons per acre.	Gain in Yield. tons per acre.
No manure (mean of 32 plots) .	24·54	—
60 lb. N. as Sulphate of Ammonia	26·26	1·72
60 lb. N. as $NaNO_3$ . . .	26·29	1·75

28 tons of pen manure was applied to the field as plant cane. The increments due to nitrogen are small but significant and might be due to chance less than once in 100 times.

(G). *Cultural Experiments*

(i) *Breaking of Banks*

It is not customary in Antigua deliberately to return the earth from the banks into the planting furrows during the life of the plant canes. In other countries it is claimed that this action is beneficial. The more important benefits may be summarised as follows:—

(1) The operation brings into closer proximity with the root system of the young plant the cultivated topsoil from which the banks are formed and the pen manure and decomposed trash which the banks contain.

(2) If the operation can be performed before the end of the wet season it provides an earth mulch around the base of the young plant which acts as a protective blanket during the dry weather which follows.

(3) It prevents water lying stagnant in the furrows or cross-holes around the base of the young plant in wet weather.

The experiments at Jolly Hill and at Cochranes have already been reported under the section dealing with the manurial effects of sulphate of ammonia on plant cane.

At Jolly Hill the mean yield of 18 plots in which banks were broken was 16·78 tons per acre and of 18 plots in which the banks were left unbroken 17·40 tons per acre.

At Cochranes the mean yields were 37·64 tons per acre and 37·26 tons per acre respectively.

In neither experiment has the operation caused any significant difference in yield.

(ii) *Cross Holing v. Open Furrows*

La Roches Estate

Soil Type: Calcareous clay tuff.
Rainfall ($13\frac{1}{2}$ months): 42 in.
Variety: Ba.11569.
Layout: Randomised Blocks.
Plot size: $\frac{1}{20}$ acre.
Planted: April 4, 1934.
Reaped: May 9, 1935.

Cultural Treatment.	Yield of Cane. tons per acre.
Open Furrows . . .	30·04
Cross Holed Furrows . .	28·72
Loss due to cross holing . .	1·32

Each figure is the mean of 16 plots but the difference of 1·32 tons in favour of open furrows cannot be established as statistically significant.

(iii) *Distance of Planting*

Thibous Estate, Big piece

Soil Type: Calcareous marl, shallow phase.
Rainfall ($14\frac{3}{4}$ months): 38·01 in.
Variety: Ba.11569.
Layout: Four 3×3 Latin squares.
Plot size: $\frac{1}{30}$ acre.
Planted: December 1, 1933.
Reaped: February 26, 1935.

Distance of Planting (Within rows).	Yield of Cane. tons per acre.
2 ft.	17·28
3 ft.	17·58
4 ft.	16·47

There is no significant difference between yields, indicating that no gain results from planting closer than 4 ft. within the row under the conditions of the experiment—small rainfall and uneven distribution—nearly 12 in. fell in November and December 1934.

In this experiment the distance between rows was kept constant at $4\frac{1}{2}$ ft. for all plots.

(*H*) *Discussion of Results and Summary*

Significant gains in yield have followed the applicant of pen manure and of filter press mud to plant canes. In both experiments the manures were applied to the growing canes at the end of the dry season so that the effects produced would appear to be due to the actual fertilising constituents of these manures rather than to conservation of moisture or improvement in tilth. The essential fertilising constituents of pen manure are nitrogen, phosphate and potash. In the case of filter press mud the chief fertilising constituents are nitrogen and water soluble phosphate.

Neither sulphate of ammonia nor nitrate of soda caused any increment in yield when applied to plant cane except in the case of the experiment on the lightly calcareous soil at Betty's Hope where dressings of 2 or 4 cwts. of sulphate of ammonia after the dry season caused small but significant gains.

It is generally stated as a result of field experience that sulphate of ammonia produces increases in yield on the non-calcareous soils of the Bendals and Jolly Hill Districts and it seems not improbable that in the case of the two experiments at Jolly Hill and Yorkes the poor rainfall, unevenly distributed, and the poor tilth resulting from late cultivation, have proved limiting factors preventing a response to nitrogen.

As regards ratoon canes large and significant gains in yield were obtained on the non-calcareous soil at Blubber Valley and on the feebly calcareous soil at La Roches, while small but significant gains were obtained on the calcareous soils at the Diamond and at Fitches Creek.

If we accept the results with plant canes at Jolly Hill and at Yorkes as anomalous and caused by the factors mentioned above it will be observed that response to nitrogen is greatest on soils containing little or no calcium carbonate. This is in agreement with experimental results obtained in Trinidad where the response to nitrogen on naturally calcareous soils or on heavily-limed soils can be very small unless ample available phosphate is present.

This theory that response to nitrogen depends on the presence of available phosphate receives confirmation from the response to pen manure and to scum cake experienced on the calcareous soils at Gaynors and Yeamans.[1]

The following table shows the varieties cultivated in the experiments at Collins and Paynters and the percentages of stalk and of joint infestation.

Variety.	Collins		Variety.	Paynters	
	% Joint Infestation.	% Stalk Infestation.		% Joint Infestation.	% Stalk Infestation.
P.O.J.2878	10·7	68·0	P.O.J.2878	32·0	100·0
B.4507	7·4	62·0	Ba.11569	27·3	100·0
B.H.10.12	7·3	62·5	B.726	24·2	98·5
Ba.11569	7·0	54·3	B.4507	24·0	97·1
B.2935	5·9	56·0	B.H.10.12	22·9	98·2
B.726	5·8	58·0	B.2935	21·4	100·0
S.C.12.4	4·3	42·5	S.C.12.4	20·6	98·6

As a mean of the two experiments the varieties may be placed in the following increasing order of magnitude with respect to percentage joint infestation: S.C.12.4, B.2925, B.726, B.H.10.12, B.4507, Ba.11569, P.O.J.2878.

[1] A significant response to soluble phosphate in the presence of nitrogen was obtained in an experiment conducted at Duers during the season 1930-1932. (*Reports on the Agric. Dept., Antigua*, 1932 and 1933.)

This order is somewhat different from that recorded in 1934 when B.4507 was less infected than the other standard varieties.

It seems probable that mean figures for a long period of years will be required to furnish even an approximately accurate estimate of varietal susceptibility.

As regards the relative efficiency of sulphate of ammonia and nitrate of soda as sources of nitrogen the experimental results indicate that there is no advantage in one form over the other. Sulphate of ammonia is the cheaper fertiliser.

It is suggested that the failure of bank breaking to produce beneficial results may be due to the fact that the experiments were not planned until January and March, respectively, so that the plants were not sufficiently advanced in growth for the banks to be broken until the advent of the dry season. The mulching value during the dry season was, therefore, completely lost. The type of banking customary in Antigua, in which the setts are planted in very deep furrows, moreover, makes breaking of banks a very difficult operation, since the covering of the furrows with the very large volume of earth contained in the banks may cause a serious setback in growth to the young tillers. Tiller counts at Jolly Hill shortly after bank breaking showed in fact that the plots in which banks were unbroken contained on an average 31 per cent. more shoots than those in which banks were broken.

In the case of the cross hole *v.* open furrows experiment, the site was on rather heavier soil than is usually chosen for this operation. On the other hand the low rainfall at the time of planting and during early growth would in general be considered as propitious to the practice of cross holing. Neither increased germination nor better growth, however, resulted on the cross holed plots.

As regards planting distance the evidence so far available indicates that under dry conditions no advantage follows planting at a closer spacing in the rows than 4 ft.

A more detailed discussion of the results reported above will be found in the paper in *Tropical Agriculture* already quoted on page 498, which embodies not only the experiments conducted by the Department, but also those conducted by Mr. C. F. Charter, Agronomist to the Gunthorpes Estates.

(iv) *Varietal Susceptibility to Moth Borer Attack*

Moth borer infestation counts were made at the time of reaping the varietal experiments at Collins and at Paynters. An account of the relation between degree of infestation and field losses in the different varieties is being published in *Tropical Agriculture.*

Root Crops

Cassava

Nigeria.—Mr. J. West, in the report of the Botanical Section, Southern Provinces, for January to June 1936, states that the attempts to breed cassava varieties which will be immune, or at least highly resistant, to mosaic, were continued (see this Bulletin, 1935, **33**, 68). This disease occurs through the Southern Provinces, and it appears to be more virulent and to spread more rapidly nearer the coast. The field tests of all varieties are therefore duplicated at Ibadan, some 100 miles inland, and at Agege, which is only about 20 miles from the coast. After two years' testing, a number of hybrid cassavas have shown no signs of mosaic infection at either station.[1] These hybrids were obtained by crossing varieties which showed resistance to the disease. They are now being used to cross with the best local varieties in order to combine mosaic resistance with the desired agricultural qualities. Over 1,100 seeds from such crosses have been planted out this year, and the plants obtained will be tested both at Ibadan and Agege.

Yams

Nigeria.—The following statement by Mr. J. West relating to the dry rot of yam tubers is taken from the report of the Botanical Section, Southern Provinces, for January to June 1936.

In a previous report (see this Bulletin, 1934, **32**, 449) a brief description was given of a disease which affects the tubers of yams in the South-Western Provinces. This disease is caused by an eelworm, which has recently been described and renamed *Anguillulina bradys* by T. Goodey ("Observations on a Nematode Disease of Yams," *J. Helminth.*, 1935, **13**, 173). A brief description of the pathology of this disease is given in the same paper.

Under native farming conditions, dry rot is not normally severe, but on Moor Plantation, where fixed rotations replace shifting cultivation, it has developed to serious proportions over a period of years. The control of this disease is being attempted by purely cultural methods, and the experiments involve the following factors: (i) time of planting; (ii) time of harvesting; (iii) treatment of cover crops before planting. The results are not yet conclusive, but some promising indications have been obtained.

The most important factor appears to be the use of healthy planting material. In its early stages the disease is extremely

[1] Latest results suggest that the apparently resistant hybrids do not all possess complete immunity at Agege.

hard to see, but the symptoms develop rapidly within four to eight weeks. In the past it has been the practice to harvest the yams in October and to plant in November. By altering the time of planting from November to February a double purpose has been achieved. The late planting does not appear to reduce the yield appreciably, whilst it shortens the time the crop is in the soil, and, consequently, the period during which it is liable to infection. Furthermore, during the three months which intervene between harvesting, in October, and planting, in February, the seed yams are kept in a yam store. All healthy material keeps very well in such a store, but diseased tubers, however lightly infected when harvested, have sufficient time to develop symptoms which are readily recognised. Consequently, completely healthy material can be selected for planting purposes.

An alternative is to plant yams in November and harvest in July, leaving the "tops" in the soil to produce small seed yams by October. These early harvested tubers come on the market when the price is high. But the method is not successful as regards disease control because there is no certainty of the planting material being healthy, and the seed yams obtained in October are liable to be thoroughly infected, and therefore useless.

Whether the cover crop is burnt or dug in green does not appear to have a very marked effect on the incidence of dry rot in the following yam crop, though there are certain indications that burning is a less effective measure.

The final results of these experiments will not be available for some years, but, as already stated, the indications so far obtained are very promising.

Fruits

Bananas

Gold Coast.—The half-yearly report of the Agricultural Department for the period January to June 1936 contains the following information relating to the local banana industry.

In May 1935 a contract with one of the shipping companies commenced whereby Government guaranteed the freight on a total of 75,000 bunches over a two-year period from that date. Shipments are made by the fortnightly mail vessels, at a flat rate of 2*s.* 9*d.* per bunch, irrespective of size. It was intended to ship 25,000 bunches in the first year and 50,000 in the second. Actually in the course of the first twelve months a total of 23,590 bunches had been exported, or 1,410 short of the first year's estimate. This shortage should easily be made up during the second year of the contract.

Bunches are bought from peasant farmers at their farms,

Government undertaking transport and shipping arrangements, prices paid to growers being 1*s*., 9*d*., and 6*d*. for 9-hand, 8-hand, and 7-hand bunches respectively. During most of the year market prices were abnormally low, the highest being 5*s*. 4*d*. per bunch, and on several occasions rather less than 4*s*. per bunch was realised. At these rates losses were inevitable, and in the first twenty-two shipments only one recouped expenses. Latterly prices have shown marked improvement, and bunches have realised as much as 6*s*. 10*d*., which affords a good profit. From data obtained during the first year there is evidence to show that the industry is not likely to be profitable unless the average value amounts to 6*s*. per bunch.

Areas have been extended and new farms made. The type most favoured by planters is the Cavendish, and few will undertake to handle Gros Michel, which is more liable to storm damage and less easy to harvest. In spite of repeated warnings peasants will not give the requisite amount of cultivation to their plots, with the result that yields have declined and the percentage of small bunches has been high. The minimum weight of bunches for export is 28 lb.

Pineapple

Nigeria.—Mr. J. West, in the report of the Botanical Section, Southern Provinces, for January to June 1936, states that a collection of local pineapple varieties is being studied at Ibadan. The Department has been carrying out experiments at Agege with the object of developing an export trade. The most suitable variety for this is Smooth Cayenne. This variety, however, is not entirely successful. It has been found that some of the local varieties possess characters which might be incorporated in Smooth Cayenne, and a breeding programme has been commenced with this object in view.

It has been found that Smooth Cayenne is normally self-sterile, but produces seeds readily when cross-fertilised. Using a simple technique, a number of seeds have been obtained which have germinated, in each case Smooth Cayenne being used as the female parent. The rate of growth of the seedlings suggests that it will take two or three years before they produce fruit.

Oil Seeds

Coconuts

Nigeria.—According to the half-yearly report of the Agricultural Department for the period January to June, the higher price for copra, which rose to £10 per ton in January but has since declined, caused a noticeable increase in the export, 2,025 tons being shipped in 1935 against 1,035 tons

in the previous year. In the Western Province the steady improvement in price acted as an inducement to farmers to extend existing holdings or make new plots and rather more than 23,000 seedlings were established. Production of good copra in the Western Province, where the rainfall is high, is intimately bound up with the use of a cheap, simple, and effective artificial drier. Such a type has been evolved and tested out by the Department and with correct initial tuition has been found to work well when left to the use of the farmers. The drier costs about £15 to erect, and on the advice of Department officers no fewer than twelve have been constructed and put into use this season.

Ground-nuts

Nigeria.—Mr. K. T. Hartley, Agricultural Chemist, Northern Provinces, in his half-yearly report for January-June 1936, states that the work on the oil content of ground-nuts, reported on previously, was repeated during the period under review. From the results which are quoted below, it is considered to be proved that the selected strain "Castle Cary" is at least as good in oil content as any other local variety when grown under the same conditions.

Oil Content—Percentage of dry matter of kernels

	Grown at				
Variety.	Samaru.	Kano.	Sokoto.	Gusau.	Daura.
Castle Cary . .	49 0	50·2	51·9	53·0	49·0
Sokoto Local . .	47 6	50·4	51·0	—	—
Gusau ,, . .	47·2	48·9	—	51·7	—
Daura ,, . .	46·5	47·9	—	—	49·7

MINERAL RESOURCES

CYPRUS

The Imperial Institute has received, from the Colonial Secretary, the following statement by the Inspector of Mines and Labour regarding mining in Cyprus during the six months ended June 30, 1936.

There was an increased expansion in all mining operations in the Colony during the period under review. Ore from the Mavrovouni mine is now treated in the new flotation plant which has been completed at Xero, the resulting product being shipped in the form of cupriferous concentrates. A larger tonnage of crude pyrites was mined and exported from the Skouriotissa mine.

The Asbestos mine, having obtained fresh financial support, operated at full capacity, but owing to adverse weather conditions during the first half of the year the output compared unfavourably with the corresponding period in 1935.

There was great activity in prospecting operations due to a search for gold, and permits have been applied for and issued over most of the known mineralised areas. Development work was continued on several of the newly discovered gold deposits, one of which was coming into production at the close of the period. A number of other occurrences are being prospected with encouraging results.

Work done by the Cyprus Mines Corporation at the Skouriotissa Pyrites Mine

	First 6 months 1936.	First 6 months 1935.
Underground development, footage	1,651	766
Mineral mined, tons	73,544	43,133
Mineral exported, tons	71,604	44,060
Underground labour (average per day) . .	736	657
Labour, surface and underground (average per day)	1,507	1,303

Work done by the Cyprus Mines Corporation at the Mavrovouni Pyrites Mine

	First 6 months 1936.	First 6 months 1935.
Underground development, footage	8,978	7,582
Mineral mined, tons	145,671	106,660
Mineral exported, tons	19,802	63,258
Concentrates exported, tons	26,782	—
Cement copper exported, tons	nil	nil
Labour, underground (average per day) . .	1,378	761
Labour, surface and underground (average per day)	2,019	1,456

Cyprus Chrome Company, Ltd., Troodos Mines

Mining operations were suspended pending the erection of a treatment plant. There was no production during the period under review.

Work done by the Cyprus Mines Corporation in the Skouriotissa and Prospecting Permit areas in the production of "Devil's Mud" (auriferous andesite)

	First 6 months 1936.	First 6 months 1935.
Underground development, footage, Skouriotissa only	5,907	17,817
Ore mined, short tons	14,694	5,710
Ore exported, short tons	475	1,594
Gold content of ore exported, troy oz. fine . .	3,099	4,632
Silver content of ore exported, troy oz. fine .	10,113	27,643
Gold bearing metallic precipitate exported, tons .	4	3
Gold content of above metallic precipitate, troy oz. fine	5,245	2,240
Silver content of above metallic precipitate, oz. fine	41,254	16,893

Tunnel Asbestos Cement Company, Ltd., Amiandos

	First 6 months 1936.	First 6 months 1935.
Rock mined, tons	484,859	269,080
Rock treated, tons	101,521	54,129
Asbestos fibre produced, tons	3,078	3,771
Asbestos fibre exported, tons	3,276	3,781
Labour, quarries only (average per day) . .	695	439
Labour, all operations (average per day) . .	1,087	834

Minerals exported other than those dealt with above were as follows:

	First 6 months 1936.	First 6 months 1935.
Gypsum, calcined, tons	2,057	3,268
Gypsum, raw, tons	7,762	2,848
Stone, building, cu. yds.	nil	2
Stone, pumice, tons	90	1,275
Terra umbra, tons	2,289	2,547
Terra verte, tons	5	18

NIGERIA

The Imperial Institute has received the following statement from the Director regarding the research work carried out by the Geological Survey during the six months ended June 30, 1936.

Gold

The examination of the goldfield has been resumed on the Kakuri and Kaduna standard sheets. The Kakuri sheet lies almost entirely within Zaria Province and includes a portion of the Kaduna river which, with its major tributary, the River Sarkin Pawa, carries out the whole of the drainage. The area is a continuation, structurally and petrologically, of the crystalline complex to the west previously surveyed and mapped. The absence in this area of schists with their gold-bearing quartz veins is reflected in the negligible amounts of gold found in the rivers. There is no definite evidence of the Nupe Sandstone Series, and it is possible the area included in the Kakuri sheet lies beyond the eastern limit of its deposition.

A rapid reconnaissance of the Kaduna sheet, which lies immediately to the north of the Kakuri sheet, shows evidence of a minor axis of elevation extending from east to west just north of lattiude 10° 40′ north. This has had the effect of deflecting the Kaduna river from a north-westerly to a south-westerly direction and also in lowering the gradient of the rivers to the north of it, notably the Tubo and Damari. Both these rivers meander in wide stretches of their own alluvium with residual lakes on each side of their courses, while the headwaters of their tributary streams are marked by marshy ground. In view of the overloading of all streams with detritus, the absence of schists and of the Nupe sandstones, it is not anticipated this area will produce much gold.

Water

The shaft-sinking programme in the Northern Provinces has been continued and resulted in 66 wells being completed during the half-year.

Sokoto Province.—Work is now concentrated in the north-west corner of the Province in both Sokoto and Argungu Emirates. Progress has not been as rapid as could have been desired, owing chiefly to the presence of tough clays and shales and to gas which necessitates artificial ventilation.

Bauchi Province.—Satisfactory progress was maintained in the north of Katagum Emirate until the advent of the rains, when it became necessary to transfer the work to the extreme south-west corner of the Emirate. Wells in this district are, as a rule, not deep, and no particular difficulties were encountered during construction.

Bornu Province.—With the exception of those in the Government station at Maiduguri, wells in Bornu and Fika Emirates are uniformly deep, depths approaching 300 ft. or more being the rule rather than the exception. Although this retards the rate of construction considerably, the work has been successful and in many wells pressure rises have been tapped.

Kano Province.—In both Kano and Gumel Emirates well sinking has been continued, and it is satisfactory to record that pressure rises ranging up to 50 ft. have been obtained in most of the wells. Owing to the lack of funds the programme in Gumel is nearing completion for the present, and all equipment is being transferred to the adjoining Hadejia Emirate and operations commenced there.

Katsina Province.—Early in the year work was commenced in the Ruma District in the west of the Province. This is an area of crystalline rocks, and the poor supplies encountered in the shafts have been augmented by belling and gallerying. Progress has been satisfactory but slower than usual owing to the large amount of blasting required.

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Die geologische Bedeutung der Halleiner Tiefbohrung. By O. Ampferer. *Montan. Rdsch.*, 1936, **28**, No. 15, pp. 8; No. 17, pp. 8. The Hallein salt deposits, Austria.

Gewinnung natürlicher Natriumverbindungen in U.S.A. *Chem. Industr., Berlin*, 1936, **59**, 709.

Sulphur

Exploitation des Amas de Pyrite du Massetano. By M. Gilardi. *Rev. Industr. min.*, 1936, No. 378, 967-972.

Talc

An Old Talc Mine Reopened and Modern Plant Built. *Rock Prod.*, 1936, **39**, No. 9, 48-51. The Southern Talc Company has been organised to mine and process talc at Chatsworth, Georgia, U.S.A.

Water

Geophysical Prospecting for Underground Waters in Desert Areas. By F. W. Lee. *Inform. Circ. No.* 6899, *U.S. Bur. Mines*. Pp. 27, 10½ × 8. (Washington, D.C.: Superintendent of Documents, Government Printing Office, 1936.)

Electrical Prospecting for Water. By A. Loehnberg and A. Loewenstein. *Min. Mag., Lond.*, 1936, **55**, 143-152. An account of geo-electrical work undertaken in Palestine with the object of controlling boring operations for water.

Water-Power in Brazil, with Special Reference to the São Paulo Development. By A. W. K. Billings. *J. Inst. Civil Engrs.*, 1936, **3**, No. 8, 677-698 (in supplement).

NOTICES OF RECENT LITERATURE

Books for review should be addressed to "The Editor," Bulletin of the Imperial Institute, South Kensington, London, S.W.7.

A SHORT HISTORY OF INDIA. By W. H. Moreland, C.S.I., C.I.E., and Atul Chandra Chatterjee, G.C.I.E., K.C.S.I. Pp. ix + 496, 8½ × 5½. (London, New York, Toronto: Longmans, Green & Co., Ltd., 1936.) Price 12*s.* 6*d.*

This is an authoritative work by two writers well qualified to deal with their subject. Mr. Moreland was a distinguished Civil Servant in India, and is the author of several important works in connection with Indian history, whilst Sir Atul Chatterjee, who was High Commissioner for India in London from 1925 to 1931, has served as a member of the Viceroy's Council and is now a member of the Council of the Secretary of State for India.

In their Preface the authors state that they "have tried to tell the story of India as it appears in the light of the most

recent research, but within a moderate compass," and that on this account their task has been "selection rather than enumeration." They have found it necessary to discard many details of secondary importance in order to concentrate on their main theme, the evolution of Indian culture and its response to successive foreign contacts.

It would be difficult to deal with so vast a subject in a more concise and illuminating manner than that presented by this interestingly written and instructive volume, the fifty chapters of which deal with subjects ranging from "The Beginnings of Indian History" to the "Unrest and Reforms" of the years immediately preceding the war of 1914-1918 and the repercussions on Indian affairs of the war itself. The book can be recommended strongly to all readers who desire information on the many-sided subject with which it deals.

Hindu Civilisation. By Radha Kumud Mookerji, M.A., Ph.D., Professor of Indian History in the University of Lucknow. Pp. xv + 351, 9½ × 6. (London, New York, Toronto: Longmans, Green & Co., Ltd., 1936.) Price 15*s*.

This well-written book is much more specialised than Moreland and Chatterjee's "History" noticed above. It aims at furnishing an account of ancient Hindu civilization, from the earliest times up to the establishment of the Maurya Empire shortly after the retreat of Alexander the Great from India. Following a short Introduction, the main sections of the book are entitled: Prehistoric India; Geographical and Social Background; The Aryans in India—Rigvedic Civilization; Later Vedic Civilization; Indian Civilization in Post-Vedic Literature; Northern India, *c.* 650-325 B.C. These titles will serve to indicate the manner in which the author has dealt with the subject—one which, as he points out in the Preface, is necessarily somewhat nebulous, and sometimes speculative and highly controversial.

The work has been suggested by the requirements of study and teaching in universities, but it can be recommended to the general reader interested in ancient India and its social, economic, and religious development.

Agricultural Organisation in New Zealand. Edited by H. Belshaw, D. O. Williams, F. B. Stephens, E. J. Fawcett, and H. R. Rodwell. Pp. xx + 818, 9¼ × 6. (Published for the New Zealand Institute of Pacific Relations by the Melbourne University Press in association with Oxford University Press, 1936.) Price 21*s*.

The sub-title of this volume is "A Survey of Land Utilization, Farm Organization, Finance and Marketing." It

is claimed in the Preface that the work is unique for New Zealand in at least two respects, viz., it represents the first comprehensive survey of agricultural organisation and land utilisation in the Dominion, and it has brought together a larger number of specialists than have ever before co-operated in one investigation in that country. The editors hope that it will provide a useful book of reference and a starting point for many further enquiries into farming problems.

A list of the specialist contributors is furnished, and other agricultural and industrial experts of the Dominion are mentioned as having assisted in the production of the work, which offers an authoritative presentation of its subject deserving the attention of agricultural economists and technologists in many countries other than New Zealand itself. Some of the statistical and other information which is given has little practical interest outside New Zealand, but even such details will be welcomed by some readers, whilst others will be mainly interested in the various aspects of such subjects as sheep, dairy, and stock farming, forestry, and the production of phormium fibre. There are chapters dealing with the geology and climate of the Dominion, with agricultural education, land tenure, labour conditions, and so on ; in fact, even the full title of the volume is by no means a complete indication of its contents, which form a very valuable addition to contemporary agricultural literature.

THE SCIENTIFIC PRINCIPLES OF PLANT PROTECTION, WITH SPECIAL REFERENCE TO CHEMICAL CONTROL. By Hubert Martin, D.Sc., A.R.C.S., F.I.C. Pp. xii + 379, $8\frac{1}{2} \times 5\frac{1}{2}$. Second Edition. (London : Edward Arnold & Co., 1936.) Price 21s.

A notice of the first edition of this useful book appeared in this BULLETIN (1929, 27, 263). During the time that has elapsed since its publication considerable developments have taken place throughout the whole field of plant protection. Particularly has important progress been made in epidemiology, in the application of synthetic chemistry, and in laboratory investigation of insecticides and fungicides. These advances have made the publication of a revised edition essential, and have necessitated the rewriting of practically the whole of the book.

Although drastic revision has taken place and sixty additional pages have been added to the text, the present edition differs very little in plan from the first, except that the discussion of biological control has been arranged to follow that of the influence of environment upon the extent of attack, thus bringing together the ecological principles. A considerable

amount of up-to-date matter has been included in sections dealing with spreaders, protective colloids, dispersing and emulsifying agents, and in a section dealing with rotenone and related insecticides.

The inclusion of a list of references to scientific literature at the end of each section is again a valuable feature of the book.

Dr. Martin's book can be strongly recommended to all who are in any way interested in the subject of the control of plant pests and diseases.

PYRETHRUM FLOWERS. By C. B. Gnadinger. Second Edition. Pp. xvi + 380, 9 × 6. (Minneapolis, Minnesota: McLaughlin Gormley King Co., 1936.) Price $5.00.

Although it is only three years since the publication of the first edition of this work, considerable progress has been made in all aspects of the pyrethrum industry. The production of pyrethrum flowers in Japan has been greatly increased, and a new source, Kenya, has entered the field. Greater interest in this material has been shown by insecticide manufacturers during this period and much attention has been paid to the study of its constituents and properties, and the evaluation and uses of the flowers. This progress is illustrated by the fact that over 300 references have been added to the bibliography, a feature which is of much value to all who desire to become conversant with the subject.

The book deals with the pyrethrum industry in a very comprehensive manner. One of the earlier chapters is devoted to a description of the commercial sources of the flowers and the methods of cultivating, harvesting, and marketing of this material in Dalmatia and Japan. Four others deal with the chemical or biological aspect of the subject and include an account of the results of investigations carried out to isolate and characterise the active principles in the flowers. Some fourteen methods are given in detail for the evaluation of this material by chemical means and their relative merits are discussed. Biological methods for the determination of the toxicity are described and the results of these tests correlated with those obtained by chemical methods. An account is also given of the work carried out by various observers on the relative toxicities of Pyrethrin I and II, the active constituents of the flowers.

Nine chapters are allotted to the industrial aspect. In these are described the comparative values of commercial grades of pyrethrum; the effect of storage, light and heat on pyrethrum products; adulteration; grinding and manufacture of extracts; household insecticides, livestock sprays,

horticultural powders and sprays containing pyrethrum. The final chapter deals with the trials made in the cultivation of pyrethrum flowers in America.

The new edition of this useful work brings up to date the information given in the original one by the addition of the most important results of the experience gained during the past three years. New processes for the isolation of the active principles are given. In the chapter on the evaluation of the flowers by chemical means five recent methods are described in addition to those detailed in the previous edition. These have all been drawn up with the view to the more rapid and accurate determination of the amounts of pyrethrins present. Two new methods have been included in the biological tests. Other important additions consist in a list of the regulations promulgated in Yugoslavia for the control of the marketing of pyrethrum ; the results of further investigations on the loss of pyrethrin content during the storage of the flowers, with particular reference to the effects of the state of maturity of the flowers and of baling ; and the method of preventing loss of pyrethrin content in concentrated extracts by the use of antioxidants. The description of cultivation trials in America is supplemented with the results of various experiments carried out in Colorado and designed to furnish increased knowledge on the effect on the yield of flowers per acre and/or the pyrethrin content of the flowers of different methods of drying them ; shading of the plants ; fertilisers and varying spacing of the plants. A new section is included giving instructions for growing the flowers.

The book is furnished with some 50 illustrations or figures, 100 tables of statistics or results, a bibliography of nearly 1,000 references and an index. It will prove of great value to all interested in pyrethrum flowers, whether as producers or consumers.

FOOD AND THE PRINCIPLES OF DIETETICS. By Robert Hutchison, M.D., LL.D., F.R.C.P., and V. H. Mottram, M.A. Pp. xxvii + 634, $8\frac{1}{2} \times 5\frac{1}{2}$. Eighth Edition. (London: Edward Arnold & Co., 1936.) Price 21s.

The great interest which has been shown during the last few years in the subject of nutrition has so stimulated research that much fresh material has been added to the store of knowledge on this subject. The authors of this standard work have consequently found it necessary to publish a new edition after a lapse of only three years. It would be impossible in this notice to attempt a detailed survey of so comprehensive a treatise, but it may be of help to those who are not acquainted

with this book if some indication of its contents is outlined here.

After chapters dealing respectively with the nature, nutritive constituents, and relative values of foods, and with the amount of food required in health, the different types of foods of animal and vegetable origin, spices and condiments, beverages, etc., are dealt with comprehensively, whilst separate chapters are also devoted to the mineral constituents of food and water and mineral waters. The cooking of foods, the digestion of food in health and the principles of feeding in infancy and childhood are fully discussed, and detailed information is included on human milk and its substitutes. The last four chapters are devoted to the principles of feeding in disease, some dietetic " Cures " and " Systems," and artificial and predigested foods and artificial feeding.

The chief changes made in this new edition will be found in the first three chapters, but minor additions and emendations have been made throughout the book, while an interesting article on " The History of Dietetics," by Dr. Hutchison, first published in *The Practitioner* a year or two ago, is included as an Introduction to the volume.

THE CULTIVATED RACES OF SORGHUM. By J. D. Snowden, F.L.S. Pp. vii + 274, 9¾ × 6¼. (London: Adlard & Son, Ltd., 1936.) Price 10s. 6d.

Since Dr. Stapf's revision of the African cultivated sorghums was published in the *Flora of Tropical Africa* (Vol. IX, 1917) a considerable amount of material had been received at Kew which made the existing classification of this important group of cereals incomplete. Before making a wider study it was decided to augment the collections still further, and to this end Mr. H. C. Sampson sought the co-operation of the Departments of Agriculture of those parts of the Empire where grain sorghums are grown. In addition to herbarium material, much useful information on the agricultural side was received at Kew in response to this appeal. The working out of the extensive collections and the publication of the present volume were made possible by the generosity of the Trustees of the Bentham-Moxon Fund. The study was entrusted to Mr. Snowden, who has had experience of the crop in the field as Economic Botanist in Uganda, and it has been carried out with a thoroughness and detail which will make it valuable to agriculturalist and systematist alike.

The book commences with a consideration of the history and nomenclature of the sorghums, going back to the time of Pliny and discussing in turn the early references, the Linnean classification as distinct species, their later subordination under

one species, and recent work in which they are again treated as distinct species.

Separate species are recognised in the classification here adopted, which follows and extends that of Dr. Stapf. This system and the significance of the different botanical characters used are discussed, and a description of the group is given, together with the geographical distribution. There is a useful plate illustrating the various parts mentioned in describing the inflorescence and spikelets.

The arrangement of the keys to the species and varieties is such that they may be used equally well by those who still prefer to treat the sorghums as varieties of one vast species. With the enumeration of species, in addition to botanical descriptions, references, and synonymy, notes are included on the history, characteristics, affinities, distribution, culture, and economics. The varieties are also described in detail with the aid of a number of figures. In conclusion the relationships of the wild and cultivated sorghums are discussed.

The extensive bibliography adds considerably to the value of the book; it is arranged chronologically under a number of sections dealing with general classification, cytology and genetics, anatomy, morphology and physiology, poisonous properties, and particular information about different groups of sorghums. The index is in three parts, the first giving botanical names, including pre-Linnean nomenclature, the second vernacular names, both native and European, and the third references to countries and regions mentioned in the text.

THE FREEZING PRESERVATION OF FRUITS, FRUIT JUICES, AND VEGETABLES. By Donald K. Tressler, Ph.D., and Clifford F. Evers, B.S. Pp. x + 369, 8 × 5½. (New York: The Avi Publishing Company, Inc., 1936.) Price $5.00.

Although in this country the preservation of fruits and vegetables by freezing has received but little attention, the process is no longer in its infancy in the United States and is beginning to fill an important place there in the field of food preservation.

A great deal of information on the subject has been accumulated during recent years, and the object of the authors of this book has been to correlate data from many sources and to present a broad survey of the general principles of selection of the raw material, its preparation, freezing, storage, handling, and preparation for the table. This task has been successfully accomplished in sixteen well-arranged chapters, and the book can be thoroughly recommended to all interested in the preservation of food.

The first five chapters deal with the principles of refrigeration, freezing processes and systems, changes occurring during the preparation, freezing, cold storage and thawing of fruits and vegetables, and with the general question of packaging. The next section of five chapters is devoted to the adaptability of fruits to freezing, the preparation and freezing of different types of fruits and fruit juices, and the use of frozen fruits in ice creams. The preparation and freezing of vegetable varieties are dealt with in a similar manner in two further chapters. The remainder of the book consists of three chapters relating to the storage, transportation and marketing of frozen fruits and vegetables, their nutritive value, and methods and precautions to be adopted when cooking them, and there is a final chapter in which the problems and future of the freezing preservation industry are discussed.

As the authors point out in their Preface no attempt is made to give detailed directions for conducting commercial freezing operations. Such a course would not be possible in a work of this size, but this limitation is to a very great extent overcome by the inclusion at the end of each chapter of a list of references to technological and scientific articles, from which further detailed information can be obtained. This inclusion of numerous references to original literature is a particularly useful feature of the book.

DISEASES AND PESTS OF THE RUBBER TREE. By Arnold Sharples, A.R.C.Sc., D.I.C. Pp. xvii + 480, $8\frac{1}{2} \times 5\frac{3}{4}$. (London: Macmillan & Co., Ltd., 1936.) Price 25s.

In his Introduction Mr. Sharples states that the aim of this book is to record the progress of pathological research in Malaya. He is in a good position to give such a record, having served in Malaya since 1913 as Mycologist to the Department of Agriculture, and from 1931 as Head of the Pathological Division of the Rubber Research Institute.

The subject is dealt with fully, and account is taken of relevant work carried out in other countries. Mr. Sharples emphasises the importance of a broad outlook in pathological work, and the necessity of giving proper consideration to all aspects of any problem of disease, especially to the influence of external factors, which is so often ignored.

The book is divided into three parts. Part I deals in a general way with plant diseases and the factors concerned in their causation. It includes a brief account of the structure, reproduction, and classification of fungi, and a chapter on their physiology. Part II gives a short description of the structure and physiology of higher plants, with particular reference to the rubber tree.

With the aid of this preliminary treatise the non-technical reader may gain a much better understanding of the diseases. These are fully described in Part III under a number of sections dealing with root diseases, tapping and panel affections, stem diseases, leaf diseases, scorching and after-effects, miscellaneous troubles and pests. There are two further chapters on the treatment of diseases and forestry methods of cultivation, and an appendix giving a list of fungi recorded on rubber trees in Malaya.

The book is illustrated with a number of excellent coloured plates, photographs, photomicrographs, and drawings. In addition to the index a bibliography, arranged chronologically, is given at the end of each section in Part III, and there is a glossary of scientific terms. The work is a valuable addition to the literature of plant pathology and should be particularly useful to the practical planter.

FOREST FLORA OF SOUTHERN NIGERIA. By Jas. D. Kennedy, M.B.E., Dip. For. (Edin.). Pp. xxxiv + 242, $9\frac{1}{2} \times 6\frac{1}{4}$. (Lagos: Government Printer, 1936.) Price 10s.

Purely botanical descriptions of forest trees are often rather unsatisfactory for purposes of identification, but here the problem has been attacked from a practical point of view. The book, which is based on over ten years' experience in Nigeria, is intended for Forestry Officers and others connected with the Southern Nigerian Forests and should prove a valuable aid to them. It is not meant for a purely botanical treatise, although there is much information included which will be helpful to the taxonomist. The descriptions of plants are accordingly given as far as possible in every-day language and details of floral characters are, as a rule, avoided. In some cases this leads inevitably to difficulty in giving descriptions sufficiently accurate to distinguish related plants, but this seldom happens with the trees, to which most attention is paid.

The book deals mainly with species found in the Rain Forest and a brief description of this and other ecological types of forest of Southern Nigeria is given in the foreword by Mr. J. R. Ainslie, the Director of Forests, Nigeria. The families are arranged as in the classification used in Hutchinson and Dalziel's *Flora of West Tropical Africa*. In the descriptions of species special attention is given to characters of the bark and bole of trees; there is also valuable information concerning the times and periods of flowering and fruiting and notes on the distribution and frequency.

No general key for identification is given, but the two Appendices will serve as useful aids in this connection. The first gives lists of species with certain easily determined "spot

characters " and a conspectus of some important families; the second a series of keys to the Nigerian *Meliaceæ*.

The book concludes with a substantial index of native names with their botanical equivalents, an index to scientific and European names and a generous allowance of blank pages for notes. The thorough treatment of the native names adds considerably to the usefulness of the work.

TREES AND SHRUBS OF KENYA COLONY. A Revision of " A Descriptive Catalogue of Some of the Common Trees and Woody Plants of Kenya Colony," by E. Battiscombe. Pp. xi + 201, $9\frac{3}{4} \times 6\frac{1}{4}$. (Nairobi, Kenya: Government Printer, 1936.) Price 5*s.*

The original Catalogue, of which a notice appeared in this BULLETIN (1927, **25**, 97), has been republished in the light of an increased knowledge of the local flora and the number of species listed has been more than doubled. The revisions and additional descriptions are mainly the work of Mr. I. R. Dale, Assistant Conservator of Forests. A brief account of the main forest types of the Colony has been included in the Introduction, but the system of classification followed remains the same, namely that of Hutchinson's *The Families of Flowering Plants*. The index of vernacular names is greatly enlarged and is subdivided into ten groups, based on language-divisions of the native tribes. There is also a separate index of English popular names. It is unfortunate that illustrations could not be included, as in the original edition, but, nevertheless, the book in its present extended form will prove of very great value to all concerned in the development of the East Africa forests.

LOGGING—TRANSPORTATION. The Principles and Methods of Log Transportation in the United States and Canada. By Nelson Courtlandt Brown. Pp. xv + 327, 9 × 6. (New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1936.) Price 20*s.*

This volume is intended as supplementary to the author's *Logging—Principles and Practices*, previously published (see this BULLETIN, 1935, **33**, 407). It has been prepared primarily as a text-book for students of forestry, but should prove of interest and service to all engaged in the logging industry. The subject is treated in the logical and detailed manner that one has come to expect in a book from the pen of Professor Brown. The book is divided into four parts. The first, entitled " Minor Transportation—Log Assemblage," deals in over 100 pages with animal skidding, tractors, power logging,

and cable hauling systems. Then follows a short section of 12 pages on "Loading for Transport." Part III (over 80 pages) on "Major Land Transportation" is concerned with chutes, wheeled vehicles (animal and tractor draught), sleds, motor vehicles, and forest railroads. The final part, "Major Water Transportation," occupies 70 pages and deals with floating and driving, river and lake rafts and booms, ocean rafts, flumes, and barges and steamers.

The numerous photographs and diagrams add greatly to the value of the work, and there is a classified bibliography of some 650 items.

CANADIAN WOODS: THEIR PROPERTIES AND USES. By T. A. McElhanney and associates in the Forest Products Laboratories of Canada. Pp. xv + 345, $9\frac{3}{4} \times 6\frac{1}{2}$. (Ottawa: The King's Printer, 1935.) Price \$1.00, paper bound; \$1.50, cloth bound.

This excellent treatise is much more than a mere description of the properties and uses of Canadian woods. Its preparation was undertaken by the Forest Products Laboratories at the request of the Lumbermen's Research Committee of the Canadian Lumbermen's Association, who assisted with advice as to the kind of publication most likely to meet the needs of the industry. This collaboration between the technical expert and the practical man has resulted in a work which in effect is a general text-book on the properties and uses of wood which will prove of great value to all interested in the timber industry wherever they may be.

After a general introduction, which includes the standards of measurement employed in the timber industry of Canada and the United States and definitions of terms and abbreviations used in the industry, a brief account is given of each of the various softwoods and hardwoods of commercial interest in Canada. Then follows a series of chapters contributed by various members of the technical staff of the Laboratories. That on the structure of wood is illustrated by photomicrographs of selected examples, and includes a key to the identification of the commoner Canadian woods. The chapter on the mechanical and physical properties of Canadian woods in relation to their use deals with factors affecting the strength of wood and with the strength of timber and timber products; tables giving the mechanical and physical properties of the woods and other data are printed as an Appendix to the book and occupy thirty-five pages. Other chapters concerned primarily with wood as a material of construction deal with the various methods employed in the seasoning of lumber, with the causes of decay and stains in wood, and with wood

preservation. In addition there is a chapter on the preparation of pulp, paper, and related products, and another entitled "The Chemical Utilisation of Wood," which deals with products, such as maple sugar and oleoresins, which are obtained directly from the tree, those prepared by the destructive distillation or steam distillation of the wood, and also various minor materials. The final chapter gives a classified list of uses of Canadian woods.

The book is well illustrated and is provided with a detailed index. Of special value is the very full list of references to literature given at the end of each of the main chapters.

THE PRINCIPAL ROTS OF ENGLISH OAK. By K. St. G. Cartwright, M.A., F.L.S., and W. P. K. Findlay, M.Sc., D.I.C. Department of Scientific and Industrial Research, Forest Products Research. Pp. v + 38, $9\frac{1}{2} \times 6$. (London: His Majesty's Stationery Office, 1936.) Price *2s.*

This useful little volume, which is intended to be the first of a series of papers dealing with the fungi causing decay in the principal kinds of timber, surveys the existing knowledge, as well as recent work carried out by the Forest Products Research Laboratory on the chief diseases of English oak. Experiments on the durability of sap-wood and heart-wood of oak are described, and the factors influencing the durability of the timber discussed. The principal fungi causing decay in standing and felled oak timber are described, and means are given for the identification of the various rots and of the fungi responsible for them. The economic aspects of the various rots of felled timber are dealt with, but the silvicultural aspects have been largely omitted. A final section deals with the stains and discoloration of oak wood, such as "golden oak," yellow, grey stains, and chemical stain. The volume is well illustrated by photographs showing the various fungi, and there is a full list of references to other publications.

PRINCIPLES OF STRUCTURAL GEOLOGY. By Charles Merrick Nevin. Second Edition. Pp. xii + 348, 9×6. (New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1936.) Price *17s. 6d.*

The first edition of this volume was published in 1931 and noticed in this BULLETIN (1931, **29**, 501-502). The second edition follows the lines of the first and shows but little change except an increase of 15 per cent. in the number of pages. Nevertheless, on comparing the two texts it is apparent that there has been a considerable amount of revision in many places and that a number of fresh diagrams and photographs

have been included. The principal change, however, is the addition of a new chapter by Dr. Evans B. Mayo on Structures associated with Igneous Intrusion. This, which has several references to the work of E. and H. Cloos and R. Balk, bears on a subject which has received considerable attention in recent years, and its inclusion enhances the value of the book to students.

The object of the work, which is to present to students the subject of structural geology in a manner calculated to stimulate an ability to reason, is well maintained in the new edition.

INDIA'S MINERAL WEALTH. A Guide to the Occurrences and Economics of the Useful Minerals of the Indian Empire. By J. Coggin Brown, O.B.E., D.Sc. Pp. x + 335, $8\frac{1}{2} \times 5\frac{1}{2}$. (London: Oxford University Press, 1936.) Price 15s.

This book is a worthy and considerably enlarged successor to the fourth volume of the series entitled "India of To-day" which was published in 1923 under its present title, and is, in fact, described by the author as a second edition. The alphabetical arrangement of the minerals employed in the earlier work has been discarded, and the present volume is divided into four parts dealing with (1) the mineral fuels, (2) metals and their ores, (3) other useful minerals, and (4) gems and semi-precious stones. These parts are sub-divided into separate chapters dealing with the various minerals according to their applications. Further improvements are the six maps, eight excellent plates illustrating various mining activities in India, twenty-one graphs indicating the progress of mineral production, and thirty-seven statistical tables.

Accounts are given not only of the geological nature of the occurrences of a particular mineral, but also of its historical development, present position, and future possibilities. Such subjects as lignite, natural gas, ferro-manganese, chromium, tungsten, tantalum, and niobium, and the non-metallics kaolin, ochres, fuller's earth, ammonium sulphate are now treated separately. Some interesting sidelights add piquancy to the book.

The book has a very comprehensive range, gives a detailed treatment of subject matter and a concise statement of the world-trade position of each mineral, which should be of value to all interested in the development of India's mineral wealth. It concludes with a bibliography on the minerals of India, together with a statement of India's mineral production in 1933 and 1934, and a good index.

La Géologie et les Mines des Vieilles Plateformes. By F. Blondel. Pp. 303, $9\frac{1}{2} \times 6\frac{1}{2}$. (Paris: Société d'Editions Géographiques, Maritimes et Coloniales, 1936.) Price 36 francs.

The author explains in his Preface that, since the greater part of France's colonial possessions are in Africa, in order to interpret in their true perspective the geological researches on these regions it is necessary to review the facts concerning other parts of the world having an analogous geological setting, regions usually known as the pre-Cambrian shields, or, to adopt the terminology of M. Blondel, " les vieilles plateformes."

The first part of the book deals with the geology of the pre-Cambrian shields; the second describes the mineral deposits they contain. Dealing with the shields in order from east to west, first in the northern and then in the southern hemisphere, leads to a natural sequence of regions with closely analogous geology. After the North American shield we pass to those of Europe, Siberia and China, and then Gondwanaland, which includes the South American, African, Indian, Australian, and Antarctic shields. There follows a chapter briefly summarising the principal characters of the basement rocks, the younger Archæan, and their topography, structure, and metamorphism. The geological section is well illustrated by sketch maps.

The second part commences with a general chapter on the distribution and types of mineral deposits. The mineral substances dealt with are coal and petroleum; copper, gold, zinc, lead; iron, aluminium, and manganese; tin, asbestos, chromium, platinum, nickel, copper, cobalt, diamond; graphite and mica. A concluding chapter reviews the relative mineral richness of different geological horizons in the shields.

The attempt to summarise in the short space of 270 pages both the geology and mineral occurrences of so large a proportion of the surface of the continents is a courageous venture. Moreover, the attempted avoidance of technical language does not lighten the author's task, as may be judged from the number of mining and geological terms explained, the index to which amounts to ten pages. The portions of the book dealing with resources are rather sketchy; thus nickel, cobalt, asbestos, aluminium, and graphite each receive a page or less; even manganese, diamonds, chromium, platinum, and mica are each dismissed in little more than a page.

The book as a whole, however, will be found very interesting to readers who require information as to the comparative geology of pre-Cambrian areas and their mineral riches.

PROSPECTING AND OPERATING SMALL GOLD PLACERS. By William F. Boericke. Second Edition. Pp. xi + 144, 7¼ × 5. (New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1936.) Price 7*s.* 6*d.*

The first edition of this useful little handbook was noticed in this BULLETIN (1934, **32**, 189). There are three principal changes in the new edition. First, the chapter on Placer Mining Machines has been completely rewritten and descriptions of several new machines which have proved their merit have been incorporated. Naturally, however, all the contrivances mentioned are of American manufacture. Second, in the new edition the values of gravels and so forth, when given in dollars, are based on gold at $35 per oz. instead of the old statutory price. Third, whereas the number of pages remains exactly the same in the new edition, the price has been reduced from 9*s.* 6*d.* to 7*s.* 6*d.*

It is an eminently practical volume which deserves its popularity.

COAL: ITS CONSTITUTION AND USES. By William A. Bone, D.Sc., Ph.D., F.R.S., and Godfrey W. Himus, Ph.D., M.I.Chem.E., D.I.C. Pp. xvi + 631, 9¾ × 6¼. (London, New York, and Toronto: Longmans, Green & Co., 1936.) Price 25*s.*

The important advances which have been made in many aspects of the study of coal are well reflected when one compares Professor Bone's earlier volume with this new treatise. The book has been entirely rewritten in the light of modern research and industrial advances, and much enhanced by a superior style of printing and binding, many additional diagrams and plates, and a wider range of subjects.

The introductory chapter reviews the change of economic position in the post-war period, and Chapter II deals with reserves of coal in Britain, a subject on which the authors are advisedly circumspect and put forward the suggestion that supplies in the United Kingdom will be exhausted in from 350 to 550 years. The authors' view of the production of oil from coal is succinctly stated as follows: "When Nature supplies abundance of petroleum for the mere drilling of a hole into the earth, it is not much that men can really afford to spend upon converting her coal to oil," and that underground storage provides a less vulnerable and cheaper method of supplying the country's needs in war time than would hydrogenation-plants. Low temperature carbonisation as an additional source of petrol receives equally drastic treatment, and it is said that even if 40 million tons of suitable coal

were available annually, and the products of distillation fully treated, we should require to double the capacity of our existing national carbonising plant in order to produce some two-thirds of our present national petrol requirements. A secondary problem would be the disposal of the large amounts of semi-coke produced.

The various proposed classifications of coal are mentioned in Chapter III, which also outlines modern ideas on the origin and formation of coals. Chapter IV describes the chemical composition of the original coal substance, and also deals with peat and its utilisation. The three succeeding chapters are devoted to the occurrence and reserves of all types of coal, a special section is devoted to the chief Carboniferous coals of the world, and special mention is made of recent progress in coal petrography.

After a detailed consideration of the chemical composition of coal, a briefer treatment of coal-oxidation (with special reference to gob-fires) and the combustion of coal, a valuable and topical section is included on the smoke nuisance and its abatement in which the authors, while describing the evils of domestic fires as soot and tar producers, applaud the fact that legislation has not been passed against the use of raw coal as a domestic fuel, and even at a later stage (p. 529) eulogise the coal-fire as "much of what is best in England." It must be said, however, that when on the subject of smokeless fuels and by-products from coal (Chapter XV) it is stated that the solution of the smoke problem lies in the production of a semi-coke at a price comparable with that of good house coal.

The preparation of coal for the market forms the subject of Chapter XVI, in which the various methods of washing and dry-cleaning coal are described. Here, perhaps, space might have been found to treat the Chance sand-flotation method. Boiler operation, design, and management are considered in the next three chapters which contain much valuable information on the choice of fuels for both Lancashire and water-tube boilers, emphasis being laid on the desirability of the carbon dioxide content of the flue gases being continuously recorded at all installations as a check upon wasteful conditions of combustion.

Pulverised coal and coal-oil mixtures as a means of using certain low-grade coals which hitherto have been difficult to market are dealt with in an instructive manner. The carbonisation of coal and the several aspects of gas manufacture are described in Chapters XX to XXIII. As a natural sequence, complete gasification of coal, and water gas generation are next considered, and are followed by fuel economy in iron and steel making, and power production from coal, the latter being

considered chiefly in connection with the generation of electricity by means of fuel.

An interesting chapter (XXX) on domestic heating contains an informative table on the relative costs, in London, of coal, gas, and electricity for the winter 1935-6, calculated on a thermal basis and shows coal to be the cheapest fuel under the conditions described.

Hydrogenation of coal is treated at length in Chapter XXXI (in addition to the short account in Chapter II), and the authors give evidence to substantiate their belief that the process is uneconomic, even assuming that the cost of production of petrol did not exceed 6d. per gal. in a free market.

The last two chapters of the book cover incandescent surface combustion as an industrial heating device, and fuel economy in industrial furnaces. That this latter subject is of vital importance to the economic operation of industrial processes is easily understood when it is realised that only about 12 per cent. of the potential heat of the fuel employed is ultimately transferred as useful heat.

Two useful author and subject indexes are included. The book is one which will undoubtedly prove of value to all concerned with the coal industry. As a conspectus of recent progress in the scientific study of coal and modern practice in the utilisation of fuels the book will be welcomed, and the authors are to be complimented on this worthy successor to the previous edition of Professor Bone's book.

STATISTICAL YEAR-BOOK OF THE WORLD POWER CONFERENCE. No. 1. 1933 and 1934. Edited with an Introduction and Explanatory Text by Frederick Brown, B.Sc., F.S.S. Pp. 111, 11 × 8½. (London : The Central Office, World Power Conference, 1936.) Price 20*s*.

The compilation of international statistics presents considerable difficulty both in obtaining suitable information and in the choice of units to form a basis of comparison. In view of this the present edition is described as a tentative effort in the work of collecting comprehensive and comparable statistics on world power resources, including solid, liquid, and gaseous fuels, water power, and electricity.

The need for a standard form of coal classification is patent in the second section, but the issue has been avoided by leaving identification of the solid fuels to the various countries concerned, the one stipulation being that only the four groups, coals, lignites, brown coals, and peat, are permissible. Limits of minimum seam thickness and maximum depth to which seams are to be included have been fixed at 30 cm. and 1,200 metres for coals and 30 cm. and 500 metres for lignites and

brown coals, while in connection with peat the content of organic matter is fixed at a minimum of 50 per cent. and the moisture content is assumed to be 25 per cent.

An excellent table of the solid fuel resources of the world is given on p. 21, but it may be noted that although no figure is given for the peat resources of Canada, estimates of reserves were published by the Canadian Mines Department in 1934 to be 199 million tons of fuel with 25 per cent. moisture.

Commendable results have also been achieved in the section dealing with wood reserves, tables being given of continental forest areas, annual quantity of wood cut and trade in wood for fuel and other purposes. These tables indicate that the U.S.A. and U.S.S.R. possess the world's chief forests and supply the bulk of the world's timber.

The United States of America predominates in the section on petroleum, but as the compilers remark, the statistics of resources are far from complete, data from the principal sources of supply being unavailable or fragmentary.

Benzol and alcohol are also included in this section on liquid fuels and it is of interest to see potable alcohol featured as a source of power. The section devoted to natural gas is principally concerned with North America.

Water power and hydro-electricity output reflect the nature of the topography and precipitation of the various countries, and the statistics show the Russian pre-eminence in available gross kw. capacity, though the Norwegian annual gross developed capacity was far in excess of any other declared output in 1933 and 1934, figures for U.S.S.R. not being given.

The general electrical energy statistics show that more than 50 per cent. of the installed capacity of the world is represented by fuel-operated plants, but that in 1933 the actual output of power was less than that of the hydro-electric installations. Further information is given in the final tables on the production of power in the mining, metallurgical, electro-chemical, and other industries.

Viewed broadly the book provides an extensive survey of world power resources in a series of tables which are both explicit and self-explanatory, and should prove of particular value to the student of these resources.

A RUDIMENTARY TREATISE ON THE MANUFACTURE OF BRICKS AND TILES. Based on the work of Edward Dobson. Fourteenth edition, thoroughly revised and rewritten and enlarged. By Alfred B. Searle. Pp. xiv + 226, $8\frac{1}{2} \times 5\frac{1}{2}$. (London: The Technical Press, Ltd., 1936.) Price 10*s*. 6*d*.

The purpose of this book as originally defined by Mr. Dobson in 1850, and adhered to in Mr. Searle's revision, is

to give "a clear description of the actual manufacture of bricks and tiles, and to explain the leading differences which exist in the manner of conducting the several operations of brickmaking." Most phases of the industry are dealt with, and the information given is concise. Possibly the subject matter in certain chapters, such as those dealing with fire-bricks and sand-lime bricks, might with advantage have been expanded, and recent developments in the industry given more prominence. The descriptions of simple processes of brick-making should appeal to those interested in the development of small local brickworks in outlying parts of the Empire, although it will probably be necessary to seek further manufacturing details in more advanced treatises before embarking upon such projects.

Mr. Searle, in his Preface, states that "students of architecture, builders, etc., are all likely to be interested in the 'art of brickmaking' whilst caring little for its 'science,'" and has, as far as possible, adhered, in his revision, to the intentions of the original author. On the whole this book gives the layman an excellent glimpse of the various methods employed in the industry, and of the pitfalls that render the manufacture of bricks and tiles a more involved task than he may have previously imagined.

Colorimetric Methods of Analysis. By Foster Dee Snell, Ph.D., and Cornelia T. Snell, Ph.D. Volume I. Inorganic. Second Edition. Pp. xxiii + 766, 9 × 6. (London: Chapman & Hall, Ltd., 1936.) Price 45s.

Colorimetric methods of analysis have become increasingly important of recent years, particularly for the determination of small quantities of inorganic constituents. Considerable advances have been made in the subject and whereas the first edition of this book, published in 1921, contained about 150 pages, the present edition comprises 766 pages and covers the field of inorganic analysis only.

The first nine chapters contain a general account of the theory of colorimetric analysis and descriptions of the apparatus employed, ranging from the simple Nessler tube to the much more precise photo-electric colorimeter. A very accurate colour comparison can be obtained with this latter instrument, which is of special interest as it can be easily adapted to the automatic control of industrial processes.

The remainder of the book is devoted to the description of the numerous colorimetric methods which have been proposed for use in inorganic analyses, including a brief account of the theory and practice of the colorimetric determination of hydrogen-ion concentration.

The authors have accumulated a considerable amount of information, and an extensive list of references is a valuable feature of the book. In a few cases critical comment is made on the method described, but in most cases the practical details have been abstracted from the literature without comment, which rather lessens the value of the book as a laboratory manual. Most of the methods appear to be reliable, but a few doubtful cases might well have been omitted or merely referred to briefly. For example, the alternative method proposed at the bottom of page 357 for the estimation of titanium in silicate minerals is not above suspicion. Again, there appears to be some confusion on page 401, where the separation of potassium fluo-tantalate from a solution of tantalite in hydrochloric and hydrofluoric acids is described.

The abstracting has been done with care, many descriptions of methods have been reproduced in full, and the book will be of great use to the experienced analyst. Although this volume deals only with inorganic constituents, its appeal is not restricted to those engaged in purely inorganic work, since chemists interested in agriculture, food production, or biology, in which the determination of traces of metals is important, will also find much useful information in it.

MATERIALS OF INDUSTRY: THEIR DISTRIBUTION AND PRODUCTION. By Samuel Foster Mersereau. Pp. xviii + 541, 8 × 5½. (New York and London: The McGraw-Hill Book Company, Inc., 1936.) Price 12*s.*

This book was originally written to meet a need felt in educational work in the United States for a more systematic study of the common materials of industry, and the selection and arrangement of the matters treated have their basis in the requirements of a course developed in the Brooklyn Technical High School.

The subject matter is divided into five chapters, three of them dealing respectively with non-metallic minerals, iron and steel, and non-ferrous metals. These chapters are subdivided into sections in which, to mention a few only, such materials as petroleum, asphalt, asbestos, lime, cement, concrete, bricks and tiles, iron ores, steel, copper, aluminium, etc., are briefly discussed. The remaining chapters concern forest products and miscellaneous materials (rubber, paints, varnishes, etc.).

The treatment as a rule includes a historical sketch, followed by a brief account of the extraction or manufacture of the material considered, and of its industrial applications. At the end of each section is a glossary of terms, and sets of questions of varying difficulty.

The book is essentially of a primary nature, intended for educational purposes. It is clearly written and well-furnished with sketches and diagrams, and should be of value to those teachers who require fundamental information about some of the principal materials used in industry.

CHEMICAL INDUSTRIES, 1936. Edited by D. M. Newitt, Ph.D., B.Sc., D.I.C., A.R.C.S., A.I.C. Pp. 382 + lxxxix, $10\frac{3}{4} \times 8\frac{1}{2}$. (London: Leonard Hill, Ltd., 1936.) Price 10s.

The present volume is the eleventh edition of a publication which for many years was known as the *Chemical Engineering and Chemical Catalogue*. Last year it was for the first time issued in this fuller and more useful form.

The book is divided into ten sections, each dealing with some particular phase of plant construction or manufacturing process. In the majority of instances each section consists of a series of notes on the subject dealt with, and, where necessary, tables of properties and constants followed by relevant advertisement matter. Attention might be drawn to two particularly interesting sections, Nos. VIII and IX. The first includes the trade names of various chemicals, and tables of constants and properties of a large number of organic and inorganic compounds, and Section IX consists of brief notes on the more important natural raw materials of perfumery, by H. S. Redgrove, B.Sc., F.I.C. Numerous references to current literature are given in the text and an extensive bibliography of technological works is also included.

Chemical Industries can be recommended as a useful reference book for chemists and chemical engineers, and also has the advantage of being an excellent trade catalogue.

BOOKS RECEIVED FOR NOTICE

ENGLISH FARMING, PAST AND PRESENT. By the Right Honble. Lord Ernle, P.C., M.V.O. New Edition, Edited by Sir A. D. Hall, K.C.B., M.A., F.R.S. Pp. xvi+559, $8\frac{1}{2} \times 5\frac{1}{2}$. (London, New York and Toronto: Longmans, Green & Co., 1936.) Price 15s.

FIFTY YEARS OF FIELD EXPERIMENTS AT THE WOBURN EXPERIMENTAL STATION. By Sir E. John Russell, D.Sc., F.R.S., and Dr. J. A. Voelcker, C.I.E., M.A., with a Statistical Report by W. G. Cochran, B.A. Pp. xvii+392, $8\frac{1}{2} \times 5\frac{1}{2}$. (London, New York and Toronto: Longmans, Green & Co., 1936.) Price 21s.

THE STUDY OF THE SOIL IN THE FIELD. By G. R. Clarke, B.Sc., M.A. Pp. 142, $6\frac{3}{4} \times 4\frac{3}{4}$. (Oxford: The Clarendon Press, 1936.) Price 5*s*.

SOIL EROSION AND ITS CONTROL. By Quincy Claude Ayres, C.E. Pp. xi+365, 9×6. (London: McGraw-Hill Publishing Company, Ltd., 1936.) Price 21*s*.

COMPOSTING TEA ESTATE WASTES. By A. G. D. Bagot. Pp. xvi+24, $7\frac{1}{4} \times 4\frac{3}{4}$. (Colombo and London: The Times of Ceylon Co., Ltd., 1936.) Price 6*s*. 3*d*.

SOME CHEMICAL METHODS OF WEED DESTRUCTION. By H. C. Long, B.Sc., and R. K. MacDowall, Dip. R.T.C., A.M.I.Chem.E. Pp. 24, $8\frac{1}{2} \times 5\frac{1}{2}$. (H. C. Long, " The Birkins," Orchard Road, Hook, Surbiton.) Price 6*d*.

THE APPLES OF ENGLAND. By H. V. Taylor, O.B.E., B.Sc., A.R.C.Sc. Pp. 266, $9\frac{3}{4} \times 7\frac{1}{4}$. (London: Crosby Lockwood & Son, Ltd., 1936.) Price 21*s*.

LATEX IN INDUSTRY. By Royce J. Noble, Ph.D. Pp. 384, 9×6. (New York: The Rubber Age, 1936.) Price $7.00.

MEMENTO DE L'INDUSTRIE DU CAOUTCHOUC. (Accélérateurs—Antioxydants—Colorants—Solvants—Agents divers—Résines, etc.) By F. Jacobs. Pp. xvi+444, $8\frac{1}{4} \times 5\frac{1}{4}$. (Paris: Société d'Éditions Techniques Cillard, 1936.) Price 65 *francs*.

PERFUMES, COSMETICS AND SOAPS. By William A. Poucher, Ph.C. Volume II. Being a Treatise on the Production, Manufacture and Application of Perfumes of all Types. Pp. xiii+426, $8\frac{1}{4} \times 5\frac{1}{2}$. Fifth Edition. Volume III. Being a Treatise on Modern Cosmetics. Pp. xi+228, $8\frac{1}{4} \times 5\frac{1}{2}$. Fifth Edition. (London: Chapman & Hall, Ltd., 1936.) Price, Vol. II, 25*s*.; Vol. III, 21*s*.

MILK AND MILK PRODUCTS. By Clarence Henry Eckles, D.Sc., Willes Barnes Combs, M.A., and Harold Macy, Ph.D. Pp. xiii+386, 9×6. Second Edition. (London: McGraw-Hill Publishing Co., Ltd., 1936.) Price 21*s*.

BUCH DER HOLZNAMEN. By Dr. Hans Meyer. IV/1. Murga-Sage. Pp. 353-464, 10×7. IV/2. Saget-Zypresse. Pp. 465-564, 10×7. (Hannover: Verlag von M. & H. Schaper, 1936.) Price, separate parts, M.6.

FOREST INSECTS. A Textbook for the Use of Students in Forest Schools, Colleges, and Universities, and for Forest Workers. By R. W. Doane, E. C. Van Dyke, W. J. Chamberlin and H. E. Burke. Pp. xii+463, 9×6. (London: McGraw-Hill Publishing Co., Ltd., 1936.) Price 25*s*.

ENGINEERING GEOLOGY. By H. Ries, Ph.D., and Thomas L. Watson, Ph.D. Pp. vii+750, 9×6. Fifth Edition. (New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1936.) Price 25*s*.

TUNGSTEN. A TREATISE ON ITS METALLURGY, PROPERTIES AND APPLICATIONS. By Colin J. Smithells, M.C., D.Sc. Pp. viii+272, 9½×6. Second Edition, Revised. (London: Chapman & Hall, Ltd., 1936.) Price 25*s*.

ALUMINIUM PAINT AND POWDER. By Junius David Edwards. Pp. 216, 9×6. Second Edition, Revised and Enlarged. (New York: The Reinhold Publishing Corporation; London: Chapman & Hall, Ltd., 1936.) Price 22*s*. 6*d*.

PRACTICAL CLAYWORKING. By Arthur E. Brown, B.Sc. Pp. 241, 8½×5½. (London: The Clayworker Press, 1936.) Price 7*s*. 6*d*.

INDUSTRIAL DUST: HYGIENIC SIGNIFICANCE, MEASUREMENT AND CONTROL. By Philip Drinker, S.B., Ch.E., and Theodore Hatch, B.S., S.M. Pp. viii+316, 9×6. (London: McGraw-Hill Publishing Co., Ltd., 1936.) Price 24*s*.

PRINCIPLES AND APPLICATIONS OF ELECTROCHEMISTRY. Vol. I.—PRINCIPLES. By H. Jermain Creighton. Pp. xviii+502, 9×6. Third Edition, Revised and Enlarged. (New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1935.) Price 25*s*.

SEMI-MICRO QUALITATIVE ANALYSIS. By Carl J. Engelder, Ph.D., Tobias H. Dunkelberger, B.S., and William J. Schiller, Ph.D. Pp. x+265, 9×6. (New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1936.) Price 13*s*. 6*d*.

VOL. XXXIV. 1936

INDEX

Scientific names and titles of books are printed in italics and personal names in capitals